MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXI. FEBRUARY 8, 1901. No. 4

E. B. KNOBEL, Esq., PRESIDENT, in the Chair.

A. Otto Hilger, 204 Stanhope Street, Hampstead Road, N.W.; and

The Rev. George Vickars-Gaskell, Grange-over-Sands, North Lancashire,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Francis Alfred Laxton Kitchin, B.A. (late scholar of Pembroke College, Cambridge), Naval Instructor, R.N., H.M.S. *Britannia*, Dartmouth (proposed by H. H. Turner); and

Richard Coad Pryor, M.A. (Trinity College, Cambridge), The Rectory, Grafton Regis, Stony Stratford (proposed by J. W. L. Glaisher).

REPORT OF THE COUNCIL TO THE EIGHTY-FIRST ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron	Grand Total
1899 December 31	253	382	635	48	1	684
Since elected	+ 2	+15	...	...	...	...
Deceased	− 7	− 6	...	− 2	...	...
Resigned	...	− 9	...	...	...	...
Removals	+2	− 2	...	...	...	...
Expelled	...	− 5	...	...	...	...
1900 December 31	250	375	625	46	1	672

Mr. Maw's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, 1900 January 1:—						
At Bankers', as per Pass-book	400	10	2			
Cheques not credited till 1900	6	6	0			
In hand of Assistant Secretary on account of Council Grant for Purchase of Books ...	8	18	9			
In hand of Assistant Secretary on Petty Cash Account	18	11	3			
				434	6	2
Dividends on £1,250 Metropolitan 3-per-cent. Stock	35	15	9			
Dividends on £932 19 0 Metropolitan 2½-per-cent. Stock	22	5	3			
Dividends on £3,400 East Indian Railway 3-per-cent. Debenture Stock	97	6	6			
Dividends on £3,200 London and North-Western Railway 3-per-cent. Debenture Stock	92	8	0			
Dividends on £3,600 Midland Railway 2½-per-cent. Debenture Stock	86	12	6			
Dividends on £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	53	14	2			
Dividends on £1,100 Commercial Gas Co. 4½-per-cent. Debenture Stock	47	4	7			
				435	6	9
Received on account of Subscriptions:—						
Arrears	119	14	0			
Annual Contributions for 1900	577	10	0			
„ „ 1901	10	10	0			
Admission Fees	35	14	0			
First Contributions	19	19	0			
				763	7	0
Composition Fees				105	0	0
Sales of Publications:—						
At Williams and Norgate's, 1899	32	19	10			
At Society's Rooms, 1900	47	10	9			
Sales of Photographs, 1900	34	13	6			
				115	4	1
Income Tax refunded by Commissioners of Inland Revenue				14	12	5
Due to Assistant Secretary on account of Turnor & Horrox Fund				2	0	11
				£1,869	17	4

Astronomical Society, from 1900 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
,, ,, for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing, &c., *Monthly Notices*	468	17	3			
,, List of Fellows and Miscellaneous ...	30	1	3			
Matrices for Special Type for Fractions (half-cost)	12	10	0			
Engraving Blocks for *Monthly Notices*	3	13	10			
				515	2	4
Computation of Ephemerides	15	0	0			
Preparation of Supplementary Library Catalogue...	15	0	0			
				30	0	0
Council Grant: Purchases for Library	8	18	9			
Turnor and Horrox Fund: Purchases for Library	12	0	11			
Binding Books in Library	46	5	3			
				67	4	11
Reproduction of Photographs				31	14	5
Eclipse Expedition: Grant to Assistant Secretary				30	0	0
Repairs, &c. to Instruments				26	2	0
Clerk's Wages	45	10	0			
Postage and Telegrams	63	19	9			
Carriage of Parcels, &c.	3	13	6			
Stationery (Spottiswoode & Co.)	5	16	0			
Stationery and Office Expenses	3	3	10			
				122	3	1
Expenses of Meetings	20	0	0			
Lantern Expenses	6	11	6			
Time Signal: Rental of Wire	5	0	0			
				31	11	6
House Expenses	67	6	5			
Coals and Gas	52	1	8			
Electric Light Expenses	9	1	9			
Fittings, Repairs, &c.	17	0	0			
Sundries	3	12	8			
				149	2	6
Lee and Janson Fund Grant				5	0	0
Bankers' Deductions on Cheques				0	1	9
Balances, 1900 December 31:—						
At Bankers', as per Pass-book	535	4	4			
Cheque not credited till 1901	4	4	0			
In hand of Assistant Secretary on Petty Cash Account	10	4	6			
				549	12	10
				£1,869	17	4

Report of the Auditors.

We have examined the Treasurer's accounts for the year 1900, and have found and certified the same to be correct. The cash in hand on December 31, 1900, including the balance at the bankers', &c., amounted to £549 12*s.* 10*d.*

During the past year no changes were made in the investments of the Society.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(Signed) RICHARD INWARDS,
HAROLD SEWARD,
DAVID SMART.

January 8, 1901.

Trust Funds.

The Turnor Fund: A sum of £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1901 January 1.

	£	s.	d.	£	s.	d.
Balances, 1900 December 31:—						
At Bankers', as per Pass-book	535	4	4			
Cheque not credited till 1901	4	4	0			
In hand of Assistant Secretary on Petty Cash Account	10	4	6			
	549	12	10			
Less due to Assistant Secretary on Account of Turnor and Horrox Fund	2	0	11			
				547	11	11
Due on account of Subscriptions:—						
1 Contribution of 5 years' standing	10	10	0			
2 Contributions of 4 „	16	16	0			
12 „ 3 „	75	12	0			
31 „ 2 „	130	4	0			
57 „ 1 year's standing	119	14	0			
2 Admission Fees and First Contributions ...	6	6	0			
	359	2	0			
Less 5 Contributions paid in advance ...	10	10	0			
				348	12	0
Due from Messrs. Williams and Norgate for sales of Publications during 1900				11	5	7
£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund.						
£3,200 London and North Western Railway 3-per-cent. Debenture Stock.						
£3,600 Midland Railway 2½-per-cent. Debenture Stock.						
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.						
£1,100 Commercial Gas Company 4½-per-cent. Debenture Stock.						
£1,250 Metropolitan 3-per-cent. Stock.						
£932 19 0 Metropolitan 2½-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instruments.						
Furniture, &c.						
Stock of Publications of the Society.						
One Gold Medal.						

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	8	...	XXXI.	134	...
I. Part 2	42	...	XXXII.	145	...
II. Part 1	51	3	XXXIII.	154	...
II. Part 2	16	3	XXXIV.	157	...
III. Part 1	65	1	XXXV.	104	2
III. Part 2	82	1	XXXVI.	187	8
IV. Part 1	77	3	XXXVII. Part 1	330	7
IV. Part 2	89	3	XXXVII. Part 2	278	8
V.	100	3	XXXVIII.	263	1
VI.	117	6	XXXIX. Part 1	228	3
VII.	140	3	XXXIX. Part 2	233	3
VIII.	124	3	XL.	248	...
IX.	130	3	XLI.	392	...
X.	142	...	XLII.	224	3
XI.	147	...	XLIII.	222	...
XII.	152	...	XLIV.	206	1
XIII.	150	...	XLV.	238	...
XIV.	358	...	XLVI.	214	2
XV.	131	...	XLVII. Part 1	2	...
XVI.	157	1	XLVII. Part 2	18	...
XVII.	140	1	XLVII. Part 3	2	...
XVIII.	132	1	XLVII. Part 4	8	...
XIX.	143	...	XLVII. Part 5	8	...
XX.	133	1	XLVII. Part 6	9	...
XXI. Part 1	244	...	XLVII.	195	1
XXI. Part 2	98	...	XLVIII. Pt. 1	227	2
XXI. 1 & 2 (together)	54	...	XLVIII. Pt. 2	229	1
XXII.	156	...	XLIX. Part 1	357	...
XXIII.	141	...	XLIX. Part 2	241	...
XXIV.	147	1	L.	233	...
XXV.	153	...	LI.	265	1
XXVI.	163	1	LII.	319	1
XXVII.	417	1	LIII.	340	...
XXVIII.	371	...	Index to *Memoirs*	619	1
XXIX.	395	1			
XXX.	147	1			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	54	...	XXXII.	106	5
II.	56	...	XXXIII.	86	...
III.	...	...	XXXIV.	65	1
IV.	...	...	XXXV.	51	...
V.	...	...	XXXVI.	25	1
VI.	41	...	XXXVII.	31	3
VII.	2	...	XXXVIII.	95	2
VIII.	152	2	XXXIX.	95	...
IX.	24	2	XL.	104	3
X.	171	1	XLI.	103	5
XI.	182	...	XLII.	111	1
XII.	105	2	XLIII.	108	2
XIII.	176	2	XLIV.	110	2
XIV.	175	3	XLV.	114	1
XV.	167	2	XLVI.	107	...
XVI.	153	1	XLVII.	122	2
XVII.	165	...	XLVIII.	117	...
XVIII.	242	...	XLIX.	108	7
XIX.	51	...	L.	108	10
XX.	31	...	LI.	110	7
XXI.	16	...	LII.	107	11
XXII.	30	...	LIII.	112	15
XXIII.	17	...	LIV.	111	14
XXIV.	22	...	LV.	124	...
XXV.	13	...	LVI.	122	3
XXVI.	9	...	LVII.	129	3
XXVII.	3	...	LVIII.	127	1
XXVIII.	70	...	LIX.	131	4
XXIX.	50	...	1st Index ...	543	1
XXX.	61	2	2nd „ ...	798	...
XXXI.	90	...			

Library Catalogue	542	...
„ „ Supplement	487	...

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LX., no complete volumes can be formed from the separate numbers in stock.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium*	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet *c* 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet *a* 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about *η Argûs*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Lœwy and Puiseux
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Lœwy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis*	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age 7^d 3^h)	Lick Observatory
26	The Moon (Age 12^d $6\frac{1}{2}^h$)	Lick Observatory
27	The Moon (Age 16^d 18^h)	Lick Observatory
28	The Moon (Age 23^d 8^h)	Lick Observatory
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Lœwy and Puiseux

R.A.S. Ref. No.	Subject.	Photographed by
32	The Moon (Age 14^d 1^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ*	
42	Nebulæ M 81, 82 *Ursæ Majoris*	
43	Cluster M 56 *Lyræ* (enlarged)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula*	W. E. Wilson
58	Spiral Nebula, *Canes Venatici*	W. E. Wilson
59	Spiral Nebula, *Canes Venatici* (enlarged)	W. E. Wilson
60	Annular Nebula in *Lyra*	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich
67	Spectrum of Sun's limb, 1898 January 22	E. H. Hills
68	Annular Nebula, *Lyra*	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula*	Lick Observatory
70	Spiral Nebula, *Canes Venatici*	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
71	Spiral Nebula, *Ursa Major*	Lick Observatory
72	Trifid Nebula, *Sagittarius*	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis*	Lick Observatory
75	Solar Surface with Faculæ	G. E. Hale
76	Faculæ and Prominences	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 *Cygni*	W. E. Wilson

Nos. 44–55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, 1*s.* 6*d.* each; lantern slides, 1*s.* each; packing and postage extra.

Unmounted prints, 1*s.* each, can be obtained to order.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).

No. 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.
„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.
„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.
„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

No. 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

„ 52. (26) Dipping needle, by Robinson.

„ 53. (27) Compass needle, mounted for variation.

„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

„ 55. (29) Box of magnetic apparatus.

„ 56. (30) Hassler's reflecting circle, by Troughton; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.

No. 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.

No. 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. Two old sun-dials.
„ 118. A $10\frac{1}{2}$-inch sixteenth-century celestial globe, on bronze tripod stand.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant with counterpoise stand, by Troughton.
„ 131. Double box sextant, by Cary.
„ 132. Equatorially mounted camera with $2\frac{1}{2}$-inch portrait lens and telephotographic enlarging lens by Dallmeyer;

iron pillar. [Presented by the executors of the late Sidney Waters.]

No. 133. 3¼-inch equatorial by Ross, with tall tripod stand, equatorial mounting, eyepieces, and micrometer. [Presented by Mrs. Mann.]

„ 134. Old transit instrument, 2-inch aperture and 3 feet focal length (without stand), formerly belonging to Dr. Longfield, of Cork. [Presented by the executors of the late R. J. Lecky.]

„ 135. Globe of Mars, by E. M. Antoniadi. [Presented by M. Antoniadi.]

„ 136. A small universal instrument by W. and S. Jones, London; the telescope 1½-inch aperture and 15 inches focal length. [Presented by Miss Moore.]

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for spectroscope.
Abney doublet lens used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.

„ 16. The *Wollaston* telescope, to Mr. R. Inwards.

„ 22. The *Matthew* equatorial, to Mr. C. Thwaites.

„ 23. The *Matthew* transit, to Captain W. Noble.

„ 28. (2) 6-inch theodolite and stand, to Dr. A. A. Common.

„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.

„ „ Wire micrometer (No. 2), to the Rev. C. D. P. Davies.

„ 30. (4) 3¼-inch equatorial and stand, to Mr. C. H. Johns.

„ „ Double-image micrometer, to the Rev. W. J. B. Roome.

„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.

„ 57. (31) Box sextant, to Dr. A. A. Common.

„ 69. (43) Telescope with rock-crystal object-glass, to Sir W. Huggins.

„ 72. (*c*) Polarimeter, to Professor C. Michie Smith.

„ 78. 9¼-inch reflector and stand, to the Rev. W. J. B. Roome.

„ 80. Box of polariscopic apparatus, to Mr. H. F. Newall.

„ 98. 2-foot 6-inch navy telescope, to the Rev. J. M. Bacon.

„ 123. 6-inch telescope, by Grubb (object-glass only), to Mr. W. E. Wilson.

„ 125. 6-inch refractor, by Simms, to Dr. A. A. Common.

No. 126. $3\frac{1}{2}$-inch portable telescope, by Tulley, to Mr. T. K. Mellor.
„ 132. The *Waters* equatorial, to Mr. E. W. Maunder.
„ 133. $3\frac{1}{4}$-inch equatorial, by Ross, to Dr. A. W. Roberts.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor E. C. Pickering, for his researches on variable stars and his work in astronomical photography. The President will lay before the Society the grounds upon which the award has been founded.

Supplementary Library Catalogue.

A supplement to the catalogue of the Society's Library, containing references to all works added to the Library between June 1884 and June 1898, has been published during the past year. Price to Fellows, 1*s*.

Change in the Form of the Memoirs.

The Council have decided to alter the size of the page of the *Memoirs*, so that in future it shall be uniform in size and in extent of letterpress with the page of the *Philosophical Transactions* of the Royal Society.

The change takes place with Volume LIV., which is now in the press, and will contain the following papers amongst others :—

I. Prof. E. W. Brown, Theory of the Motion of the Moon, containing a new calculation of the expressions for the coordinates of the Moon in terms of the time. Part III., Chapter VI.

II. Mr. William Coleman, Micrometrical Measures of Double Stars, 1897–99.

III. Rev. W. Sidgreaves, On the Connexion between Solar Spots and Earth Magnetic Storms.

The Council have to record with profound regret the death of Her Majesty Queen Victoria, who throughout the whole of Her reign was the Patron of the Society.

The Council have prepared the following Address to be offered to His Majesty King Edward VII.

To the King's Most Excellent Majesty.

May it please Your Majesty,

We, the Royal Astronomical Society, humbly beg leave to approach Your Majesty with the expression of our deep and respectful sympathy on the death of our late Sovereign, our beloved Queen Victoria.

Her noble life and constant devotion to the welfare of Her subjects commanded our reverence and won our deepest affection.

We look back with pride upon the advancement of science and the progress of the arts that Her glorious Reign has witnessed; and we rejoice that it was our special privilege that it pleased Her to extend to our Society throughout the whole of Her Reign the same gracious patronage that we had received from His Majesty King William the Fourth.

But while we deplore the loss of so beloved a Sovereign, we hail with the most heartfelt satisfaction and congratulation the accession of Your Majesty to the throne of this great Empire, being fully assured that under the auspices of Your Most Gracious Majesty the welfare and prosperity of the Empire and the advancement of science and art will be fully maintained and promoted.

We pray that Your Majesty with Your Royal Consort may, under the blessing of God, be granted both health and happiness and a long and prosperous Reign.

This Address was read by the President at the Annual General Meeting, and the Fellows present signified, by rising in their places, their desire to join in offering the Address to His Majesty.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—J. S. Ancona.
Thomas Buckney.
Lord Farnham.
James Gill.
J. E. Keeler.
E. J. Lowe.
John McLandsborough.
Horace Pearce.
W. T. Radford.
Sir Josiah Rees.
T. G. Rylands.
C. Piazzi Smyth.
J. H. Young.
Associates :—J. E. Keeler.
Robert Luther.

Joseph Supino Ancona, the eldest son of the late Leon Ancona, was born in London on the 4th of September 1819 ; and died at his residence, Fernleigh, South Norwood, on the 16th of July 1900, in his 81st year, after long suffering from angina pectoris. His early wish was to take Holy Orders and he went to Cambridge with that intention ; but his father's loss of fortune about that time made this course impossible and he became an architect and surveyor. He took a keen interest in astronomy, and became a Fellow of this Society on the 10th of March, 1854 ; but he never published any work on the subject. He married young ; his wife died in 1881. They had no family.

Thomas Buckney was born at Camberwell, London, on the 1st of December 1838. He was connected nearly all his life with the business of Messrs. E. Dent & Co., clock and watch-makers of London, becoming superintendent of the manufacturing department in 1864 and a partner in 1872. A few months later, on the death of his father, he became senior acting partner, and senior partner in 1881. His knowledge of his business was sound and thorough, and extended from watches to the largest turret-clocks. He was the designer of electric contacts for

marine chronometers, and one of his latest and best works was the great clock recently erected at Gloucester Cathedral. He took a special pride in the going of "Big Ben" at the Houses of Parliament, Westminster, which was made by his firm, and in 1887 drew the attention of the Society to the fact that the clock had gone from March 29 to July 6 without any alteration, remaining within 2 sec. of true Greenwich time. From the purely astronomical point of view perhaps his best work was the construction of the Sidereal Standard Clock at Greenwich, in 1871. The clock was to have Airy's escapement (described in Vol. III. of the *Trans. Camb. Phil. Soc.*), and the more delicate parts of this escapement Mr. Buckney made with his own hands. But Airy had ordered a heavy mercurial pendulum, and Mr. Buckney convinced himself from experiments made at the time that a zinc and steel pendulum was preferable, as it would respond to changes of temperature much more readily. The mercury compensation had a sluggish action "due to the more slender parts of the pendulum (the rods and spring) taking up the new temperature very quickly, whilst the bobs, being much more bulky, required a much longer time to do this. . . . . Considering the matter, it occurred to me that if we were to eliminate from the compensative action of the zinc and steel pendulums the expansion of the bob, which we could easily do by suspending it at its centre of gravity, and rely entirely on the zinc and steel tubes and rod, matters would be very much improved, as then the compensation would be effected by parts having pretty much the same bulk, and therefore likely to act simultaneously. And so it turned out. . . . In the end I determined to lay the matter before Sir George Airy, and request his sanction to the removal of the mercurial pendulum from the Greenwich clock, and the substitution in its place of a zinc and steel pendulum on the new principle." (*Monthly Notices, R.A.S.*, xlvi., pp. 464–65). That the clock has been a success a glance at any of the subsequent Greenwich volumes will show. In 1880 Mr. Buckney read a paper to this Society suggesting a method of enclosing a clock in an air-tight case, winding it electrically by currents set up by itself. He was a constant attendant at the meetings of the Society (of which he was elected Fellow in May 1880) until recent years. Those who attend the meetings have become accustomed to glance at their watches when the bell rings, knowing that the signal represents accurate Greenwich time. They are indebted for the introduction of this signal to the kindness of Mr. Buckney, who arranged that hourly signals should be sent from Messrs. Dent's to the Society's rooms free of charge ; the Society only repaying the rental of the wire charged by the Post Office. His death took place at his residence in London after a short illness on the 1st of February 1900, at the age of sixty-one.

Somerset Henry Maxwell, 10th Baron Farnham, representative Peer of Ireland, J.P., D.L. county Cavan, Lieutenant

88th Regiment (retired), of Farnham, county Cavan, Ireland, died the 22nd of November 1900.

Baron Farnham, son of Richard Thomas Maxwell, son of 6th Baron Farnham and of Charlotte, daughter of Rev. Henry P. Elrington, D.D., Precentor of Ferns, was born the 7th of March 1849, at Newtonbarry, county Wexford, was educated at Harrow, and married Florence Jane, seventh daughter of the 3rd Marquess of Headfort. He had four sons and two daughters. The eldest son having died from the result of an accident immediately after his coming of age, he is succeeded in the title by his second son, the Hon. Arthur Kenlis, born on the 2nd of October, 1879.

As Major Somerset Henry Maxwell his name will be remembered in connection with the land troubles in Ireland in 1881, as he took a prominent part in the resistance made by the landlords against the encroachments of the Land League, and led the expedition fitted out to help Captain Boycott and others on this occasion.

He devoted himself largely to scientific pursuits, more especially to microscopy and astronomy, and had a small but very complete observatory, containing a Grubb 6-inch equatorial and accessories, fitted up at Arley Cottage, on the banks of Lough Sheelan, where he resided until he succeeded to the title in 1896.

In order to ensure the best observing conditions, his observatory was established at some little distance from the dwelling-house, but no considerations of inconvenience or fatigue deterred him from the systematic pursuit of his astronomical labours. He collected a considerable number of double-star measures, and calculated out the orbits himself.

He was anxious to help fellow-workers, and will long and gratefully be remembered by many in the north of Ireland for the prominent part he took in the organising and carrying on of the Ulster Astronomical Society, established in 1890. He was Vice-President of this Society (the President being the Rev. Dr. Hamilton, President of Queen's College, Belfast). He delivered many valuable lectures in connection with this Society.

Later on, other pressing duties having prevented him from devoting so much of his time to this work, the Society was amalgamated with the Belfast Society for the Extension of University Teaching, but there is no doubt that much of the interest in astronomical matters existing at present in Ulster is due to his personal efforts to bring the subject before the public in an attractive and interesting form.

By his will he leaves his natural history collection in trust to the Hon. Judge Boyd and Sir Howard Grubb, F.R.S., and his astronomical observatory to Sir Howard Grubb, F.R.S., and Mr. W. E. Wilson, F.R.S., to be dealt with at their discretion for the benefit of science.

Lord Farnham was elected a Fellow of the Royal Astronomical Society on the 9th of December 1887, and contributed

a short note to the *Monthly Notices* in 1889 (vol. l. p. 34) on "Observations of the Conjunction of *Mars* and *Saturn*."

James Gill was born on the 14th of May 1840, near Port St. Mary, Isle of Man, and though early attracted to the sea and bearing for many years the courtesy title of 'Captain,' he chose rather to train others in navigation and seamanship than to seek a command for himself. To the Mercantile Marine in Liverpool he rendered a very important service by the careful training and instruction he gave to many officers. For many years he was the Principal of the Navigation School at the Sailors' Home, and occupied such a commanding position as a teacher that when the Liverpool Corporation decided to found a school of Nautical Astronomy under their own supervision Mr. Gill was elected to the Head Mastership. In September 1892 the Nautical College was opened with the intention of providing a more thorough and efficient course of instruction than was demanded by the Board of Trade certificates. Mr. Gill loyally recognised the views and intentions of the Corporation, and for eight years he struggled not unsuccessfully against the superficial methods of tuition which had too long obtained in nautical circles. With the view of promoting a sounder study of navigation he published *A Text-Book of Navigation and Nautical Astronomy* (Longmans, 1898), which has attained considerable success.

Mr. Gill was elected a Fellow of this Society in January, 1888, but from a much earlier date he had given assistance to the Liverpool Astronomical Society, and in later times the meetings of this Society were held in apartments in the Nautical College. For some time he was President, and by his influence contributed not a little in keeping this Society together. He died on the 9th of January 1900, leaving a widow and three children.

Edward Joseph Lowe was the only surviving son of the late Mr. Alfred Lowe, of Highfield House, Nottingham, where he was born on the 11th of November 1825. At the age of fifteen he began an important series of meteorological observations, which were continued down to the time of his removal (in 1882) to Chepstow, Monmouthshire. He published in 1846 "A Treatise on Atmospheric Phenomena," and two years later began to assist the late Professor Baden-Powell, of Oxford, in his work on luminous meteors, and the results of their observations, which extended over a number of years, were communicated to the British Association. Mr. Lowe was elected a Fellow of this Society on the 14th of January 1848, and read his first paper in April 1849, on "Observations of Solar Spots at Mr. Lawson's Observatory, Bath," in which some curious phenomena are described. "The *umbra*, which was of an elongated form, opened in the centre, and so divided it into two parts; it always opened from the lower edge, and was alternately open and closed at intervals of 15^s; this was very sensible, and the experiment

of marking the time which elapsed between the openings was repeated many times." In a footnote is described the "simple and neat" contrivance for registering the positions of spots which was simply a reticule of small squares now known as the *réseau*. Papers which followed were on Meteors and on the Zodiacal Light, which Mr. Lowe observed assiduously. He wrote several very interesting papers on meteors and fireballs in *Recreative Science* and other publications. He observed the eclipse of 1860 at Fuente del Mar, near Santander, making a very complete series of meteorological observations which showed the temperatures at various heights above the ground, amount of cloud, amount of light, &c., during the eclipse (*R.A.S. Memoirs*, vol. xli.). And his activities extended to other branches of science. In the R.S. Catalogue of scientific papers is a list of 46 papers by him (up to 1883) on a great variety of subjects. He invented the dry powder tests for ozone in the atmosphere; he was an ardent naturalist, publishing works on conchology, on British ferns, grasses, and plants. His experiments on the hybridisation of ferns produced some remarkable results, which, however, were not generally accepted as genuine.

He was one of the founders and original Fellows of the Meteorological Society, a Fellow of the Royal, the Geological, the Linnæan, and other learned Societies. He married in 1849 Miss Annie Allcock. His death occurred on the 10th of March 1900, at his residence, Shirenewton Hall, Monmouthshire.

John McLandsborough was the eldest son of Andrew McLandsborough, of Kells, in Scotland, who had settled at Otley, in Yorkshire, where his son was born on the 3rd of May 1820. Young McLandsborough was educated in Otley, principally in the grammar school of that town. He was apprenticed to a currier and leather merchant, but after completing his indentures, finding the occupation uncongenial, he obtained employment on the Ordnance Survey, and soon became an expert surveyor. Desiring to be a civil engineer, he spent several years with the late Mr. John Miller, a civil engineer, in Edinburgh, and returning to Yorkshire he commenced practice in Bradford in 1850. His experience in Scotland had been chiefly in connection with the laying out and construction of railways, and he did similar work in his general practice at Bradford. Besides work for other companies, he was instrumental in inducing the Midland Railway to extend their line to Otley and Ilkley, and he was engineer for the line between Keighley and Oxenhope. He was also greatly interested in sanitary engineering, and carried out various waterworks undertakings at Shipley, Horsforth, and Clitheroe, besides drainage works at Burley, Yeadon, and many other places.

When quite a young man Mr. McLandsborough started a Mutual Improvement Society, afterwards merged in a Mechanics' Institute, of which he became a member of the committee of

management. He was always much interested in the institutions of Bradford, and at his death left a fine collection of British minerals and fossils, which he had formed, to the Cartwright Memorial Hall, and about 250 volumes of scientific books to the Central Free Library.

In 1868 he established a meteorological station at Bradford, and commenced a series of daily observations, which are still carried on by Mr. H. A. Johnson, now Mr. McLandsborough's successor in business. He was one of the original members of the Yorkshire Naturalists' Union, and one of the oldest members of the Yorkshire Geological and Polytechnic Society. He was greatly interested in astronomy, and had for many years a good reflecting telescope, by Browning, mounted at his residence at Manningham, near Bradford.

He married Miss Robinson, of Knaresborough, who, with two daughters, survives him. He retired from business in 1882, and continued to reside at Manningham till his death on the 24th of February 1900, in his eightieth year. He was elected a Fellow of the Society on the 14th of March 1873.

Horace Pearce was the youngest son of Mr. Francis Pearce, of Hadley Lodge, Shropshire, and was born on the 21st November 1838. He was for a long period private secretary to the late William Orme Foster, Esq., of Apley Park, Bridgnorth. A man of quiet, retiring habits, he took a great interest in science, being a Fellow of the Geological Society and the Linnæan Society, a member of the Swiss Alpine Club, the Birmingham Naturalist Society, and the Worcestershire Naturalists' Field Club, of the last of which he was president for some years. He was also on the general Committee of the British Association. He had not been in good health for some time, and left England for the South of France in the end of 1899, without, however, deriving much benefit from the change of climate. After a serious illness of about a week, he died, on the 19th February, 1900, at his residence, The Limes, Stourbridge.

He was elected a Fellow of this Society on the 14th of January 1887.

William T. Radford was born at Exeter on the 21st of November 1810. The elder son of Mr. Peter Radford, a physician connected with the Devon and Exeter Hospital, and his wife, formerly a Miss Mackintosh. He was sent to Dr. Carpenter's school at Bristol, and had among his school-fellows James Heywood, Philip Worsley and T. B. Potter. Later he went to Dublin, boarding in the house of James Martineau and studying at Trinity College, where he took the degrees of M.B. and M.D. He walked the hospitals but never practised as a doctor. In 1839 he and his mother (his father having died when he was a child) came to reside with his younger brother at Sidmount, Sidmouth, which continued to be his home until he died on the

19th of May 1900. He devoted himself chiefly to the study of science (especially meteorology) and art, spending some months of each year in London and travelling a great deal on the Continent; he visited most of the capitals of Europe and nearly all the principal cathedrals. When at home he devoted much time to microscopic studies and also worked a great deal with his telescopes, particularly one by Steinheil, $4\frac{2}{10}$ ins. diameter, with which he resolved many double stars, but no record of the results of his observations can be found. He collected an extensive and valuable library, which was particularly rich in illustrated works, and in books of reference on most subjects. He also had a number of engravings, art photographs, cameos, bronzes, &c. About thirty years ago he began giving away spectacles to the poor lace workers of the district, carefully testing their sight; this charity gradually extended to others who were in need until, when shortly before his death he was obliged by failing health to give up seeing any more applicants, he had given away more than 32,000 pairs. He was unmarried. He retained his faculties and his interest in scientific, artistic and general literature until a very short time before his death, which was sudden at last from heart failure.

He was elected a Fellow of the Society on the 13th of January 1865.

At the beginning of 1900 there were four names in our list of Fellows with date of election prior to 1850—viz. James Glaisher (1841), Sir Josiah Rees (1844), C. Piazzi Smyth (1846), E. J. Lowe (1848). Of these we have to deplore the loss by death of the second, third, and fourth.

Sir Josiah Rees was the son of the late Mr. J. Rees and was born in 1821. He was called to the Bar at the Middle Temple in 1851 and was a revising barrister on the South Wales and Chester circuit from 1865 to 1877. In 1878 he was appointed Chief Justice of Bermuda, and he was also judge of the Vice-Admiralty Court of Bermuda and President of the Legislative Council. He was knighted in 1891. In 1876 he married Eliza, daughter of Mr. J. Acock, of Cheltenham; she died in 1887. The death of Sir Josiah Rees occurred in November 1899, but the news did not reach us until after the close of the year. He was elected a Fellow of this Society on the 10th of May 1844, being proposed by the late Admiral Smyth.

Thomas Glazebrook Rylands was born at Warrington on the 24th of May 1818, and died at his residence, Highfields, Thelwall, Cheshire, on the 14th of February 1900. He was a wire manufacturer, ironmaster, &c., but found time to develop an interest in many sciences—entomology, botany, geology, mineralogy, zoology, and, later, astronomy. He was a regular attendant at the meetings of the British Association. He did not publish any astronomical work, though for a number of

years he constantly used his equatorial and transit. Several years before his death he vested these instruments in trustees for the benefit of the city of Liverpool; they were originally mounted at the Nautical Academy in Colquitt Street, and when the Corporation erected a Technical Institute they were transferred to suitable mountings on the roof of that building.

In 1893 Mr. Rylands published privately a handsome volume entitled *The Geography of Ptolemy Elucidated* (University Press, Dublin), in which by careful investigations he seeks to establish and demonstrate, by beautiful diagrams, a higher degree of accuracy in Ptolemy's writings than he had been previously credited with. A copy of the work is in the Library of the Society, presented by the author.

Mr. Rylands bequeathed to the University Library, Liverpool, a large number of books containing MSS. and early printed works, of which a Catalogue has just been printed at the Liverpool University Press. In the Preface to the Catalogue Principal Dale says :—"The collection is the most valuable that we have yet received in any single gift."

He was a good Greek and Latin scholar and an able mathematician, and possessed a fair knowledge of architecture, heraldry and ancient geography. He was a Justice of the Peace for Warrington and Mayor of Warrington 1858–59.

He was married twice, and leaves a widow, two sons and a daughter.

He was elected a Fellow of this Society on the 12th of January 1866.

The father of the late Charles Piazzi Smyth, the well-known Admiral Smyth, spent the early years of his married life on the Mediterranean Station. At Palermo he made the acquaintance of the venerable Italian astronomer, Giuseppe Piazzi. The Admiral and his wife (Annarella, daughter of T. Warington, Esq., of Naples), who is still remembered as "a lady of great ability and rare accomplishments," were so much interested in the studies of their distinguished friend that they named their second son, who was born at Naples on the 3rd of January 1819, Charles Piazzi Smyth. The celebrated astronomer acted as godfather, and at the christening expressed the desire that the child might become an astronomer. When the boy was about eleven years old his father, who had settled at Bedford, bought what was then considered a powerful telescope, and erected the well-known Bedford Observatory. One can easily imagine with what enthusiasm the Admiral pointed out the various constellations to his clever children and taught them the rudiments of astronomy, for, besides Charles, there were two sons and several daughters. The eldest son, Sir Warington Smyth, became Professor of Mineralogy at the Royal School of Mines. The third son is General Sir Henry Smyth. One of the daughters married Sir William Flower, late Director of the Natural

History Museum, South Kensington ; another, who is mentioned as the special companion of the Admiral, died before her parents ; while yet another daughter is Mrs. Baden-Powell, mother of the hero of Mafeking.

At the age of ten years we find Piazzi Smyth a pupil at the Bedford Grammar School, which he left when he was sixteen and went to the Cape as assistant to Mr. (afterwards Sir Thomas) Maclear. The way in which he at once assisted Maclear in observing Halley's Comet, and, in particular, his characteristic drawings of the comet published in *R.A.S. Memoirs*, vol. x., show how much he had profited by his home training in astronomy and astronomical drawing. In 1843 he made a series of observations of the great Comet of that year, extending from 5th March to 19th April with a $3\frac{1}{2}$-inch portable telescope, which seems to have been the largest instrument then available at the Cape for extra-meridional observations. He also depicted in oils the appearance of the great Comet as seen in the late evening twilight, with its slender and somewhat plumed tail stretching far up into the sky.

Apart from sharing in the routine work of the Observatory, he took a particularly active part in the Verification and Extension of La Caille's Arc of Meridian, which had been preceded by an interesting triangulation for connecting La Caille's Observatory, the modern Observatory, and Sir John Herschel's large Reflecting Telescope. He also shared in the measurement of the Zwartland Base, which lasted from 30th October 1840 until 5th April 1841, and which required the co-operation of no less than twenty-six persons. But several of these seem to have been frequently prostrated by sickness due to exposure to violent winds alternating with great heat.

In the triangulation Piazzi Smyth seems to have had a full share of work at the loftier stations, including Kamies-Sector Berg, 5141 feet high ; Winter Berg, 6818 feet, occupied from July 9 to October 10, 1844, and mentioned by Maclear as "a difficult snow-capped mountain in the winter season" ; and, lastly, Sneeuw Kop, 5211 feet, occupied from November 22, 1844, to July 21, 1845.

Piazzi Smyth then returned to the Observatory, preparatory to leaving the Cape for Edinburgh, where he had been appointed successor to Henderson as Astronomer Royal for Scotland and Professor of Practical Astronomy in the University of Edinburgh. But he delayed his departure for a time in order to facilitate the extension of the triangulation to Cape L'Agulhas, and did not sail for England until the 22nd October 1845. He carried with him the best wishes of Maclear, who speaks of him as "experienced in the details of meridian work, and unflinching in hardships," and adds that "he had a happy talent, with the assistance of his pencil, in conciliating the inhabitants, . . . and his robust constitution fitted him for taking an active share in the triangulation."

On arriving in Edinburgh he made it his first duty to complete the reductions of the observations accumulated by his predecessor, Thomas Henderson. In this work he was ably seconded by the late Alexander Wallace, who held the post of first assistant from the time of Henderson's appointment in 1834 until 1880. The collected results of these observations were eventually published in *Edinburgh Observations*, vols. xiv. and xv. When Piazzi Smyth commenced a further series of observations with the beautiful transit instrument used by his predecessor, he was at once confronted by a serious difficulty which had already been recognised by Henderson. This was the great susceptibility of the instrument to changes of temperature. After much skilful and patient observation, the disturbances were eventually traced in great part to the expansion and contraction of the regulating screws attached to the Y's. The adjustable Y's were discarded in 1848, and the stability of the instrument was thereby much increased. In 1851 Professor Smyth proceeded to Norway in company with Dr. T. R. Robinson, of Armagh, to observe a total eclipse of the Sun. Owing to clouds the eclipse itself was not seen; but, thanks to very complete preparations, Piazzi Smyth was able to make a number of sketches showing the various effects of light, shade, and colour incidental to the passage of the dark shadow of the Moon. Two of these sketches were reproduced in chromo-lithography in *Edinburgh Observations*, vol. xii., and Sir Robert Ball, in the *Story of the Sun*, also makes use of the Professor's unique sketches and verbal description to convey a vivid impression of the sudden darkness and the weird bordering of distant light, which are characteristic features even when the actual eclipse is hidden by clouds.

In 1856 Professor Smyth married Miss Jessie Duncan, who throughout the long period of forty years of their married life acted as his enthusiastic and indefatigable helpmate in all his work and accompanied him on all his journeys. In the same year Piazzi Smyth was in a position to carry out a long-cherished plan, viz. to undertake an astronomical expedition to the Peak of Teneriffe in search of Newton's "most serene and quiet Air, such as may perhaps be found on the tops of the highest Mountains above the grosser clouds." He fixed on this particular mountain on account of its being readily accessible in a fairly low latitude, and easy of ascent. In May 1856 the Admiralty entrusted him with a scientific mission to the Peak, placing 500*l.* at his disposal. At the same time Robert Stephenson, M.P., invited him to make use of his yacht "Titania" of 140 tons, for the whole time of the expedition. Preparations were pushed forward so eagerly that already in June Professor and Mrs. Smyth embarked in the "Titania." The chief instrument taken out was a beautiful and very complete equatorial of $7\frac{1}{4}$ inches aperture by T. Cooke & Sons, lent by Mr. Pattinson of Newcastle-upon-Tyne. The first station occupied in Teneriffe was the summit of Guajara at a height of 8900 feet on the

southern wall of the "crater of elevation," distant some five miles from the Peak itself. The Professor and his wife remained at Guajara from 14th July till 20th August. The experiences of camp life gained while engaged on the Cape geodetic operations here stood the party in good stead; hence, with the help of three "isleños" and a couple of men from the yacht a substantial temporary observatory was soon rigged up and the work of the expedition begun. From the very first Piazzi Smyth was delighted with the sharp definition and perfect steadiness of the stellar discs and their surrounding diffraction rings as shown in the 3·6-inch Sheepshanks equatorial from the Edinburgh Observatory; this in itself went far to prove that the "most serene and quiet air" did really exist "above the grosser clouds." A series of measures of the Moon's radiant heat was rewarded by an encouraging degree of success, confirming as they did the earlier experiments of Melloni by showing that the heat received from the full Moon was not altogether inappreciable. His examination of the solar spectrum at various hours of the day was conducted in such manner as to turn to the best advantage the unique conditions under which he worked. It was clearly recognised that the Fraunhofer lines were partly of solar and partly of terrestrial origin. The rapid increase in the number and blackness of the atmospheric lines as the Sun approached the horizon was carefully depicted in a series of drawings of the solar spectrum with the Sun at zenith distances ranging from 12° to 91°·1. The meteorological features of the region above the clouds were perseveringly studied with the hygrometer and black-bulb thermometer. Drawings were made of the lower cloud strata, while the "battle of the clouds" that heralded the breaking up of the summer season on the Peak was described with singular felicity. To bring out the diurnal phenomena more clearly recourse was had to the method of term-days introduced by Sir John Herschel. These observations were in part made simultaneously on board the yacht lying in Vera Cruz roads and on the summit of Guajara.

Though on the whole Piazzi Smyth had much reason to be satisfied with the work accomplished on Guajara, yet the dust-haze which from time to time impaired the clearness of the atmosphere made him wish to test the atmospheric conditions at a yet higher level. Accordingly on the 21st of August a move was made to Alta Vista, 10,700 feet above sea-level, where, after many difficulties had been overcome, the Pattinson equatorial was successfully installed on the 3rd of September at the highest point accessible to mules. The next afternoon the companion to *Antares* was seen twenty minutes before sunset, with powers of 160 to 500, both with direct and transparent-reflector eyepiece. At night the instrument was found to perform admirably on close double stars: concerning γ_2 *Andromedæ* the Professor writes "Duplicity of B, C at once apparent, powers 350 to 800; C is smaller than B; they are seen as two separate stars with a

dark line between them, though at the same time they somewhat compress each other's discs." *Jupiter*, then in good position, presented the magnificent spectacle so skilfully depicted in the well-known drawings published in *Edinburgh Observations*, vol. xii., and in *Phil. Trans.* for 1858. The many-sided genius of the Professor was strongly brought out on an excursion to the summit of the Peak. He gives a most interesting description of the various zones of lava streams, and fully accounts for the presence of a population of birds and insects in the terminal crater by the moisture due to steam given out by the volcano. The famed ice-cavern, from which the camp obtained their supply of water, was explored and described. The remarkable instance of lateral refraction recorded by Humboldt, which had been a puzzle to scientists for half a century, is discussed, and attention drawn suggestively to the fact that the observation was made in the neighbourhood of the well-known "narix" or blow-hole, where Smyth himself found the barometric readings to be altogether abnormal. Unfortunately autumn burst in on the observing party much earlier than was expected, and forced upon Piazzi Smyth the conviction that at a high level the seasons occur much more in accordance with the solstices than is the case at lower elevations. Accordingly this notable "Astronomer's Experiment" was concluded on the 19th of September. The results of the expedition were published in a *Report on the Teneriffe Astronomical Experiment of* 1856, *addressed to the Lords Commissioners of the Admiralty*, 4to, London and Edinburgh, 1858; and, with some omissions, in the *Phil. Trans.* for the same year; while much of the detail and certain enlarged photographs are included in vol. xii. of the *Edinburgh Observations*. These valuable photographs show the difference of the actinic transparency of the air at a height of 10,700 feet and at sea-level. In *Teneriffe, an Astronomer's Experiment: or, Specialities of a Residence above the Clouds*, 8vo, London, 1858, the general reader with astronomical tastes will find one of the most fascinating volumes ever written. Its interest and permanent value are much enhanced by the score of photo-stereographs with which it is illustrated.

A voyage to Russia by way of the Baltic was undertaken in 1859, an account of which is given in *Three Cities in Russia*, 2 vols. 8vo., London, 1862. Here, again, an additional charm is lent to the narrative by Smyth's own characteristic illustrations. The astronomer's interest in these volumes naturally centres in the description of the great Observatory at Pulkowa. The venerable designer of that famous establishment, W. von Struve, was unfortunately absent, but the honours of the place were most hospitably done by his son Otto and the distinguished staff of Associate Astronomers.

Our Inheritance in the Great Pyramid, a volume published in 1864, shows how much Piazzi Smyth's thoughts were at this time occupied with that wonderful monument; and it is there-

fore not surprising that we find Professor and Mrs. Smyth settled at Gizeh in the beginning of 1865. Here he measured the Great Pyramid as to its orientation, the size and slope of its great passages, and the dimensions of its inner chambers. The greatest care and accuracy were bestowed in finding the dimensions and cubic content of the sarcophagus in the King's Chamber. These investigations are discussed with much detail and illustrated by many plates in *Edinburgh Observations*, vol xiii., a volume which will always be regarded as a standard work of reference on the metrology of the Great Pyramid. The value of these measurements, and the skill with which they were made, were fully recognised by the Royal Society of Edinburgh, who awarded the Keith Prize to Professor Smyth in 1867. So much public interest had been aroused by these investigations that Piazzi Smyth was induced to issue a work of three volumes in a more popular form entitled *Life and Work at the Great Pyramid*, which was followed in 1868 by yet another volume *On the Antiquity of Intellectual Man, from a Practical and Astronomical point of View.* It is much to be regretted that these volumes are largely interspersed with mystical speculations to the great prejudice of their scientific value. Unfortunately this tendency displayed in his works on the Great Pyramid led to controversies with the Council of the Royal Society of London, which culminated in Piazzi Smyth's withdrawal from the Society in 1874.

Shortly afterwards the indefatigable Professor engrossed himself with Spectroscopy. He worked at the Solar Spectrum, the Spectra of Luminous Gases, of the Aurora, and of the Rain-band. The occasion of a visit to Palermo in the spring of 1872 had been utilised in making spectroscopic observations of the Zodiacal Light, the spectrum of which he found to resemble closely that of very feeble twilight (*Monthly Notices*, vol. xxxii. p. 277). Finding it practically impossible to study the Solar Spectrum to advantage in the smoky atmosphere of Edinburgh, we again see Piazzi Smyth in 1877 transport his instruments to a sunnier climate, which this time he found in Portugal. Here he addressed himself to an examination of the red end of the Solar Spectrum, and certainly made notable progress in the resolution of the great bands in that region into their constituent lines. His results were communicated to the Royal Society of Edinburgh and published in the twenty-ninth volume of their *Transactions* ; and in 1880 he was awarded the Makdougall-Brisbane Prize for these researches. Four years later we see him start for Madeira, again in quest of sunshine. With improved apparatus, including a Rutherfurd grating with 17,296 lines to the inch, he succeeded in completely resolving many of the more difficult groups of lines in the visual spectrum of sunlight. The results of this excursion were given to the world in a handsome volume entitled *Madeira Spectroscopic*, 4to, Edinburgh, 1882. Piazzi Smyth's most detailed survey of the Solar Spectrum was accom-

plished in Winchester in the summer of 1884. The object of this work was partly to ascertain whether the great volcanic eruptions of 1883 had in any appreciable degree affected the absorptive power of the Earth's atmosphere. On this occasion the apparatus used was rendered more perfect by the addition of a magnificent Rowland grating. The outcome of this interesting survey appeared in a memoir, illustrated by sixty-one coloured plates, entitled "The Visual, Grating and Glass-lens Solar Spectrum (in 1884)," contained in vol. xxxii. Part II. of the *Edinburgh Transactions.*

In connection with his reseaches in Solar Spectroscopy he carried on an extensive series of laboratory investigations, in the course of which, in conjunction with Professor Alexander Herschel, he discovered the rhythmical relation between the chief lines of carbonic oxide gas. These remarks are set forth in the following papers: "End-on Illumination in Private Spectroscopy, and its Applications to both Blow-pipe Flames and Electric Illumined Gas-vacuum Tubes," 1879; "Carbon and Carbo-Hydrogen spectroscoped and spectrometed in 1879," and "Micrometrical Measures of Gaseous Spectra under High Dispersion," 1886.

In the hours of relaxation from his purely scientific labours Piazzi Smyth turned his inventive genius, with the same eagerness that characterised all he did, to the field of mechanical invention. A problem which long attracted his attention was the construction of a "free-revolver stand" on the principle of the gyroscope, for the steady support of scientific instruments at sea. An apparatus of this kind was tried with considerable success on the voyage to Teneriffe. Unfortunately the spinning motion had to be imparted by means of a rope pulled from time to time by the all-too-willing sailors: an important axle gave way just when the experiment seemed most promising. It is much to be regretted that this important invention has never been further developed. The excitement of the Crimean War turned the Professor's thoughts to the construction of a portable distance measurer. On his Russian journey he was alike surprised and delighted to find that a Russian astronomer had hit upon identically the same construction at the same exciting epoch. In 1852 an ingenious system was devised of signalling the time from the observatory on Calton Hill by means of a time-ball. This was supplemented in 1861 by a time-gun at Edinburgh Castle and the establishment of sympathetic clocks in various parts of the city. Eventually Dundee was included in the circuit. In this work he was ably assisted by James Ritchie & Son, the well-known Edinburgh clockmakers. To meteorology he made many important contributions, amongst which may be mentioned his discussion of the readings of the rock thermometers established on Calton Hill in 1837, in their relation to the sun spot period and the mean temperature of Scotland.

In 1888 Piazzi Smyth resigned his position as Director of the

Observatory and Professor in the University which he had held for forty-three years, and with his wife retired to a country house near Ripon, which was named Clova in remembrance of a place in Aberdeenshire where Mrs. Smyth had spent part of her life. Here he continued his work with unflagging zeal, photographing the Solar Spectrum on a large scale with the help of the Rowland grating; he also secured a beautiful series of photographs of typical cloud formations. After the Professor's death the negatives of these latter photographs were generously presented to the Edinburgh Royal Observatory by Mr. W. B. Dunlop of Edinburgh.

In 1896 Mrs. Smyth, the faithful and indefatigable sharer of all his labours, succumbed to a long and painful illness. After her death the Professor led even a more retired life than before, though still occupied with astronomical problems.

He died at Clova on the 21st of February 1900, and was buried beside his wife in the churchyard of Sharow, a parish some two miles distant from Clova.

On glancing back at Professor Piazzi Smyth's life, thus imperfectly sketched, one cannot but admire his indomitable energy and activity and the great versatility of his mind. He was a keen observer of Nature, and thanks to his skill alike with pen and pencil he succeeded in interesting a world-wide circle of readers in the objects in which he himself was interested. His contributions to sidereal astronomy, to mountain astronomy—to which he gave an impetus that cannot be over-estimated—and especially to spectroscopy will always secure him a high place amongst the scientific workers of the Victorian era. Though he was of a retiring disposition, those who came in contact with Piazzi Smyth were attracted by the gentle amiability of his manner and by his readiness to impart full particulars of the investigation on which he happened to be engaged.

Professor Smyth was a Corresponding Member of the Academies of Science of Munich and Palermo, and a Fellow of the Royal Societies of London and Edinburgh. He received the honorary degree of LL.D. from the University of Edinburgh, and was elected Fellow of this Society as far back as 1846.

R. C.

James Henry Young, a son of the late Captain J. H. Young of Jersey, was born at Gorey, Jersey, on the 23rd of January 1858. He was educated at the Victoria College, Jersey, and at the age of 18 entered the Civil Service in the Office of Works, in which appointment he continued up to the time of his sudden death on the 24th of September, 1900. He married in 1879 Miss Mildred E. C. Jerrold (a granddaughter of Douglas Jerrold), and leaves five children. He graduated as B.Sc. at the London University in 1892. He was accustomed to public lecturing, some of the titles chosen being "Star-myths and what has become of them," "Sun-spots," "The Earth's Future," "Sixty

Years of Astronomy," &c., &c. He was elected a Fellow of this Society on the 12th of May, 1893.

The two Associates whose loss the Society has suffered during the last year were near the two ends of the illustrious list. Robert Luther was one of the oldest, and Keeler one of the youngest. Keeler might well have been elected earlier on his merits, but there was a difficult preliminary question of procedure to be settled —viz. whether a Fellow of the Society was eligible as an Associate. (For Keeler was one of several eminent American astronomers whom we are proud to have as actual Fellows, having joined the Society on the 14th of March 1890.) In 1898 the Council decided this question in the affirmative, and forthwith Barnard, Burnham, and Keeler were elected Associates on the 9th of December 1898. The first two were already also medallists of the Society ; and there can be little doubt that only his premature and lamented death robbed Keeler of a similar honour, for his work was brilliant in quality, and he was an untiring worker. For the following particulars of his life the Council is chiefly indebted to the sympathetic and able notice by his successor in the directorate of the Lick Observatory, Professor W. W. Campbell (*Astrophysical Journal*, November 1900), to which reference should be made for a fuller account.

James Edward Keeler was born in La Salle, Illinois, on the 10th of September 1857, of a long line of New England ancestry. The family removed to Mayport, Florida, in 1869, and here Keeler not only prepared himself by private study for the university, but began his astronomical work. He drew the planets at a 2-inch telescope, and constructed a transit circle, rough in appearance, but, no doubt, capable of giving good results in the hands of its skilful maker. The circle was of wood, with a paper graduated scale, and the clock was a "small kitchen affair, and kept execrable time. It had no second hand. . . . A tall pine tree nearly on the meridian served for purposes of collimation" (*Pub. Ast. Soc. Pacific*, xii. p. 169).

Keeler entered Johns Hopkins University, Baltimore, in 1877, and graduated in 1881 ; but some weeks before taking his degree he was appointed assistant to Langley at the Allegheny Observatory. Langley was just starting for the summit of Mount Whitney to make his determination of the value of the "Solar Constant," and Keeler accompanied him on the expedition. His work for the next two years was concerned with the results obtained. He then spent a year in Europe, attending lectures in Heidelberg and Berlin on physics and mathematics, returning to the Allegheny Observatory in the summer of 1884 to help Professor Langley with his researches on the infra-red portion of the spectrum.

Early in 1886 Keeler was appointed assistant to the Lick Trustees, and, reaching Mount Hamilton on the 25th of April, he established the time-service more than two years before the

Observatory was completed and transferred to the University of California. On this completion in 1888 he was appointed astronomer in charge of the spectroscopic work, in addition to the time-service. In the three years which followed he produced some brilliant results, especially those relating to the motion of the nebulæ in the line of sight. Taking advantage of the fact that, other things being equal, high dispersion does not weaken the brightness of a monochromatic line, Keeler used a grating for these faint objects, and the wave-lengths were measured in the third and fourth orders of spectrum. There was no available comparison line for the line measured (the principal nebular line at λ 5007·05), but Keeler ingeniously deduced the wave-length of this line from observations on the *Orion* nebula, which he independently found (from the β line of hydrogen) to be receding from the solar system at about 18 km. per second. The velocities of thirteen planetary nebulæ were thus found to vary from -65 to $+48$ km. per second, and are accordingly of the same order of magnitude as those of the stars.

In 1891 Keeler was summoned to succeed Langley at the Allegheny Observatory, and here he continued his spectroscopic successes. His main piece of work there, on the spectra of Secchi's third type stars, remains still unpublished ; but everyone will remember his wonderful photograph of the spectra of *Saturn* and his rings, which first directly demonstrated the meteoric character of the ring, inferred theoretically by Clerk-Maxwell many years ago.

In 1898 Keeler was again called upon to return as Director to an observatory at which he had previously been an assistant—this time to the Lick Observatory. The tragedy of his early death is enhanced by the warm words of recognition of what he did in his few years of office, spoken by Professor Campbell in the name of the whole staff. "I but faintly reflect the views of every member of the staff," he writes, "and, indeed, of all who have been interested in the work of the Lick Observatory, when I say that his administration was completely successful. He cherished and promoted ideal conditions in this ideal place. He made a success of his own work in a splendidly scientific manner, and he saw to it that everyone had every possible opportunity to do the same. No member of the staff was asked to sacrifice his individuality in the slightest degree. Nor were demands made for immediate results. The peace of mind of the investigator, so absolutely required for complete success, was full and undisturbed."

The work he chose as his own on his return to Mount Hamilton was not spectroscopic as before, but the photography of nebulæ with the Crossley reflector. It was one of the strongest traits in Keeler's character that he was ready to adapt himself at once to new conditions ; and in the rather frequent changes of his all too short working life this capacity was of the greatest value to him. "He comprehended the possibilities and limitations of his situation," writes Professor Campbell, "and adapted himself to

them." Thus when he returned to Allegheny as Director, his spectroscopic researches were largely confined to the orange, yellow and green regions of the spectrum, since they would be less strongly affected by the smoky sky for which that vicinity is famous ; and yet by attending to such limitations he managed to produce his beautiful photograph of the spectrum of *Saturn*. When he returned to the Lick Observatory he found the spectroscopic work in the able hands of Professor Campbell, and himself therefore undertook the solution of a troublesome question —or rather what had been a troublesome question before he came. The Crossley reflector, the 3-foot reflector with which Dr. Common showed the way in the photography of nebulæ, afterwards acquired by Mr. Crossley of Halifax, had been presented by him to the Lick Observatory. The assistants told off to work with it failed to secure any good results, and blamed the instrument as antiquated and almost worthless. The new Director himself undertook to see what was wrong. He found a good deal capable of improvement and spent five months making one change after another. His account of this work (*Astrophysical Journal*, June 1900) is a model of clearness and completeness. At the end of this time the instrument immediately produced pictures of marvellous beauty in abundance. Keeler set himself to photograph the whole of Herschel's nebulæ, and had done more than half at his death. The plates record incidentally a large number of new nebulæ, and he estimated that the number to be discovered by the Crossley reflector could not be less than 120,000. The important fact that more than half the nebulæ turn out to be spiral in form was established from these plates, and has an important bearing on the theory of the cosmogony.

His death was very sudden. He became weak in health in the summer of 1900, being unable to throw off a cold contracted in June, and left the observatory on the 30th of July, with no anxiety, to secure medical treatment and take a holiday. Increasing difficulty in breathing led him to seek skilled assistance in San Francisco on the 10th of August ; the dangerous condition of his heart, which had been weak for some years, was realised on the next day ; and on the 12th of August a stroke of apoplexy proved fatal.

He had the Rumford Medal of the American Academy in 1898, and the Henry Draper Medal in 1899. He was an editor of *Astronomy and Astrophysics*, and subsequently of the *Astrophysical Journal*, and a member of many learned Societies. He was, as above recorded, both a Fellow and an Associate of this Society. He married on the 16th of June, 1891, Miss Cora S. Matthews, at Oakley Plantation, Louisiana, and leaves two children. H. H. T.

By the death of Dr. Robert Luther the Society loses one of its oldest Associates, and one who occupied a noteworthy position in the list. There are still three illustrious veterans who were elected

Associates on the 12th of May 1848 (Faye, Galle, O. Struve), but the next now in sequence form another trio with date the 11th of May 1866 (Auwers, Foerster, Safford). The first three are all that remain of a group of twenty-one, elected when the Council first undertook the suggestion of names, which had been previously left to individual Fellows; and of twenty-one further elections in the years 1849 to 1865 (none, however, being made in the six years 1856 to 1861) Robert Luther was the sole survivor, the date of his election being the 9th of June 1854. He was a marvellous discoverer of minor planets in the days when photography had not made the discovery easy. His first discovery was No. 17, made in 1852; and though Graham, of Cambridge (who discovered No. 9 in 1848), outlives him, the fact that Luther also discovered *Glauke*, No. 288, in 1890 makes his record quite unique.

Carl Theodor Robert Luther was born at Schweidnitz on the 16th of April, 1822. His father, F. H. A. August Luther, had distinguished himself in the war of 1813–15, gaining officer's rank and the Iron Cross, but had lost his right arm in the attack on St. Amand in June 1815. He learnt to write with his left hand, and obtained a civil appointment, marrying in 1818; but his health had been shattered by his wound, and he was pensioned in 1823. From that time to his death in 1844 his life was one long illness, in which he was devotedly nursed by his wife, who died in 1853. Their only son, Robert, born in 1822, went to the Gymnasium at Schweidnitz, 1831 to 1841; thence to the University of Breslau, and (in 1843) to that of Berlin. Here he remained after his father's death in 1844, studying under Encke, Dove, and others, taking a share in computations for the *Astronomisches Jahrbuch* for 1849, &c., doing some laborious work under Encke on cometary orbits, and taking a part in the Berlin observations from 1847 onwards. When Brünnow left the Bilk-Düsseldorf Observatory for Berlin in 1851, Luther was appointed, on the strength of many recommendations, his successor at Düsseldorf. Here, for twenty-six years, his only instrument was a 6-foot refractor, with ring-micrometer; and, on the advice of Argelander and Hülsmann, he used this instrument for planetary observations, and thus was in regular communication with the Bonn, Berlin, Hamburg, Vienna, and other Observatories. He discovered his first small planet on the 17th of April 1852, which was named *Thetis* by Argelander, and the discovery so delighted the people of Düsseldorf that they honoured the event with a public banquet in the *Tonhalle*, or Concert Hall, at which Argelander assisted. Luther was, moreover, so much encouraged by this success, and the recognition of it, that he refused to leave Düsseldorf for better appointments elsewhere, and the little Observatory has to thank him for crediting it with twenty-four planetary discoveries in all, besides three in which he failed to secure priority. In the years 1852 to 1861 he was

seven times awarded the Lalande prize for different discoveries. His small salary was increased by the town after his fourth discovery, and again in 1860; in 1861 the State also supplemented it. He was twice decorated by the King, in 1855 and 1863; and many other honours were conferred upon him by learned societies. He was elected an Associate of this Society in 1854.

In the years 1854 to 1857 he prepared the Berlin star-chart for 0^h, containing 4302 stars; and he was no less diligent in computation than in observation. It was due to his computations that Goldschmidt rediscovered the planet *Melete*, which had been thought to be *Daphne*; and in the *Berliner Jahrbuch* for 1865 it is recorded how Luther had rediscovered and reobserved the planets *Calypso* and *Daphne*, which had not been observed for four and six years respectively. Among his numerous calculations may be specially mentioned those of the orbits of *Hebe* (1847–1900), *Parthenope* (1850–1901), *Melete* (1857–1901), *Danaë* (1861–1900), *Glauke* (1890–1901). He worked with the greatest assiduity all his life, and it was specially appropriate that he was elected Associate of the K. Leopoldino-Karolin. Deutsche Akad. der Naturforscher in Halle," whose motto is *Nunquam otiosus*, for Luther only took four holidays from 1852 till his death.

He married in 1859 Fräulein Caroline Märcker, who was born at Essen in 1823 and still survives. Their only son, Alexander Wilhelm Luther, born in 1860, became an Assistant in the Düsseldorf Observatory in 1892, and succeeded his father as Director in 1900.

Robert Luther died on the 15th day of February 1900, after an illness of only three days. H. H. T.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.

Transit Circle.—10,438 observations of transits and 9595 of zenith distances were made in 1900, about 2000 of these observations having been made below pole. The total number of stars observed is about 4500, some 1400 of these being within 10° of the pole.

By the end of this, the fourth year of observation, all stars that are intended to form part of the third Ten Year Catalogue have been observed at least once, with six exceptions, all lying outside the circumpolar zone that forms the principal subject of observation. To complete five observations for every star within two degrees of the pole, with at least two observations on each side of the pole, only two observations are required.

The Sun was observed 182 times with the transit circle, its horizontal diameter 146 times, and its vertical diameter 154 times.

The Moon was observed 123 times ; the mean error in R.A. of Hansen's Lunar Tables with Newcomb's corrections is $-0^{s}.129$. The errors since 1883, when Newcomb's corrections to Hansen's tables were introduced into the *Nautical Almanac*, are as follow :—

	s		s		s
1883	+0·031	1889	+0·010	1895	−0·066
1884	+0·018	1890	+0·020	1896	−0·088
1885	+0·024	1891	+0·079	1897	−0·154
1886	+0·029	1892	+0·083	1898	−0·160
1887	+0·059	1893	+0·034	1899	−0·101
1888	+0·090	1894	−0·016	1900	−0·129

The planets have been observed as usual, and amongst them *Eros*, of which small planet ten observations have been secured since October. The R—D discordance agrees closely with that

found in 1899 ; in both years it is slightly larger than it was in 1897 and 1898, the correction to the D observation being :—

$$+0''\cdot08 + 0''\cdot22 \sin \text{ZD in } 1899$$
$$+0''\cdot09 + 0''\cdot32 \sin \text{ZD in } 1900$$

The second Ten Year Catalogue of 6892 stars for 1890 has been printed, and some advance copies have been received. The special object of the catalogue was the re-observation of the stars contained in Groombridge's Circumpolar Catalogue (1810), as wel. as of fundamental stars, and it thus provides material for a discussion of the co-latitude and the refraction, as well as for a determination of the proper motions of Groombridge's stars, which has been made provisionally for 174 stars having a proper motion of at least $0''\cdot1$ in R.A. or N.P.D. As a preliminary step in the determination of the proper motions of all the Groombridge stars—4000 in number—a new reduction of Groombridge's observations has been undertaken, and is steadily progressing. The observations made in 1806 and 1807 are completely reduced to 1810·0, and the observations of 1808 will soon be completed. The clock star and azimuth star places have been derived from Professor Newcomb's fundamental catalogue, as also the places of stars used for polar points. There are 15 double transits of *Polaris* which give a mean place practically identical with that derived from Newcomb's catalogue ; and the places of the other close polars depending on Groombridge's observations of *Polaris* made on the same day, agree well on the whole with Newcomb's catalogue places. As it was apparent that the observations of the standard polars were not sufficiently numerous to give azimuth errors for every day's observations, a supplementary list of stars whose places depend on observations on days on which some of the standard polars were also observed was drawn up, and these stars where necessary have been used for the determination of azimuth errors. In this way the Right Ascensions are made as far as possible perfectly fundamental. Nearly the whole of the stars within 10° of the pole were observed in 1807, and the new places are not very different from the original catalogue places, with one notable exception—viz. Groombridge 1119. Beyond 10° from the pole the effect of the revision is to reduce the discordances between Groombridge and Newcomb's fundamental system to a small fraction of their original amount. Groombridge's instrument being reversible, the results of the two positions have been kept separate, and comparison shows a very close agreement between the two.

The north polar distances are strictly differential, and the polar points are on the average derived from six or more fundamental stars, so that the zero point is well determined. From comparison between the old and new places it is found that the corrections to the former practically agree with those given by

Boss; the results in both positions of the instrument are very fairly accordant.

The Altazimuth.—This reversible instrument has been used in all four positions in the meridian and also occasionally out of the meridian. During the year 1629 transits and 1504 zenith distances have been observed in the meridian, and 68 azimuths and zenith distances in other azimuths. The Moon was observed 27 times in right ascension and zenith distance on the meridian and twice in other azimuths. The subjects of observation have been the Sun, Moon, planets and fundamental stars; also stars for which accurate places are required by Sir David Gill in connection with heliometer observations of major planets; and comparison stars for the opposition of *Eros* in 1900, from the list in the circulars of the *Eros* Committee of the Astrographic Conference.

One hundred and forty-five observations of stars both by reflexion and direct, and eighteen observations by reflexion only, have been made during the year.

Regular observations of flexure have been made throughout the year.

In October a re-determination of the division errors of the 45° divisions was made for the fixed circle, the microscopes of the movable circle being temporarily mounted on it as supplementary microscopes. It is intended to continue these observations so as to obtain the division errors of the circles by the process of subdivision of arcs of each circle separately for comparison with the results obtained by the symmetrical process previously used, in which both circles were observed simultaneously, and arcs of the fixed circle were compared with different arcs of the movable circle, on the other side of the axis. This will be taken in hand as soon as the observations of the *Eros* comparison stars come to an end for this season.

Equatorials.—Occultations of 17 stars and of *Saturn* by the Moon have been observed by one or more observers during the year. Observations of the partial eclipse of the Sun were made on May 28. These observations are given in *Monthly Notices*, vol. lxi. 4.

28-inch Refractor.—Measures of distance and position-angle have been made of 388 double stars, each star, when the components are under 1″·0 apart, having been observed on the average on $2\frac{1}{2}$ nights. Of the 388 stars 111 were under 0″·5 apart, 116 between 0″·5 and 1″·0, 87 between 1″·0 and 2″·0. Of the remaining 74 over 2″·0, a large part are third stars with close pairs, and others are difficult on account of the difference in magnitude. The following list gives a few of the more interesting stars measured during the year :—

	Mags.	Dist.		Mags.	Dist.
		"			"
Capella	1 , 1	0·1	42 Comæ	5·5 , 5·9	0·3
κ Pegasi	3·9 , 5·0	0 1	β 883	7·0 , 7·0	0·3
β 1266	7·2 , 7·5	0·1	γ^2 Androm.	5·0 , 6·2	0·3
β 524	6·0 , 7·0	0·2	OΣ 269	6·5 , 7·0	0·3
β 525	7·0 , 7·0	0·2	β 552	6·9 , 10·2	0·4
68 Comæ	6·5 , 8·0	0·2	ζ Herculis	3·0 , 6·5	0·6
Σ 2367	7 0 , 7·5	0·2	OΣ 225	5·2 , 11·2	0·8
ε Hydræ AB.	3·5 , 6·0	0·2	Procyon	1 , 10	4·8
ζ Bootis	3·5 , 3·9	0·2	Aldebaran	1 , 14	31·4

Good sets of measures of 70 *Ophiuchi*, β 883, ζ *Herculis*, and κ *Pegasi* have been obtained, the last-named star, which is now at an interesting part of its orbit, having been observed on fourteen nights since last July.

The observations of greatest interest made during the year are those of *Capella* as a binary star. On April 4 it was found that there was a distinct elongation, and measures of position-angle were made and have been continued at every favourable opportunity through the year. The observations from April 4 to May 29 are given in *Monthly Notices*, vol. lx. No. 9, and the observations from July 10 to December 10 with a provisional orbit and a brief discussion in *Monthly Notices*, vol. lxi. No. 2. Since these were published observations have been obtained on six nights in December and January which are in satisfactory accordance with them. κ *Pegasi*, which is now quite as difficult an object as *Capella*, the distance of the components being less than 0″·1, has been observed recently on six of the nights on which *Capella* was observed.

Thompson Equatorial.—Work with this instrument has been almost entirely confined to the 26-inch refractor, with which 274 photographs have been taken during the year. Of these photographs 161 are of *Eros*, the planet being shown with measurable images on 122 of them, taken on fifty-two nights. The series was begun on July 18, and eighteen photographs were taken on sixteen nights between this date and September 25 for the position of the planet. Photographs were taken whenever possible from October 1 onwards in positions giving the largest available parallactic displacement on both sides of the meridian, and also on the meridian, and successful photographs were secured on thirty-six nights between October 1 and December 31. Similar observations were made with the Astrographic Equatorial, and photographs have been secured on forty-seven nights between October 1 and December 31.

A good series of photographs of Comet *b* 1900 was obtained, the comet being successfully photographed on eighteen nights.

Nineteen successful photographs of double stars and three of *Neptune* and his satellite were obtained, the occulting shutter being used, and 18 plates of *Polaris* and *Regulus* for parallax. Of the remaining photographs, 14 were of the *Pleiades* and *Præsepe* for examination of the distortion of the object-glass, 22 for adjustments of the object-glass on the equatorial, and 12 were taken to test plates in view of the eclipse of 1900 May 28.

With the reflector two photographs of the cluster M 37 *Aurigæ* (exp. 2^h and 1^h) and two of the *Pleiades* (2^h and $2\frac{1}{4}^h$) have been taken in the principal focus. Thirty-two photographs have been taken for the adjustment of the spectroscope, but the spectroscopic observations had to be discontinued owing to pressure of other work inconnection with the eclipse in May, and in the latter part of the year owing to the observations of *Eros*.

Astrographic Equatorial.—580 plates, with 1579 exposures, have been taken on 145 nights. Of these 101 have been rejected, viz. 10 because the exposure was interrupted by cloud, 16 because the plates did not come up to the standard in showing faint stars, 29 owing to bad guiding or wrong setting, 13 for photographic and 18 for miscellaneous defects.

Of the 494 successful plates, 153 were for *Eros*, now just past opposition, the planet being shown with measurable images on 153 of these, taken on 47 nights between October 1 and December 31. Of the others, 168 were for the Chart, 137 for the Catalogue, 12 for adjustments, 6 for typical areas, and 3 for the field round Comet *b* 1900.

The following table shows the progress of the photographic mapping of the heavens to the end of 1900 :—

	Catalogue.	Chart.
Number of successful fields on 1899 December 31	1050	1062
„ „ „ taken in 1900	137	168
Number previously passed, rejected in 1900	67	127
Number of successful fields, 1900 December 31	1120	1103
Number still required	29	46

Positives on glass of 120 chart plates were made during the year, which, with the 990 reported last year, make a total of 1110, of which 34 are duplicates.

During the year 1900 152 plates were measured in both direct and reversed positions of the plate by two measurers, who measured the 6^m and 3^m images respectively. The measurement of the Greenwich zones is completed from 64° to 74° N. Dec., with about half of the zone between 74° and 75°, making a total of 687 plates out of 1149, and covering about 1388 square degrees out of 2087. The total number of stars measured in this area is 105,000, while the number in the B.D. is 14,975. The average

number of stars measured per square degree is 75, which is almost exactly 7 times the number in the B.D.

The printing of the measures has been completed for zones 65°, 66°, and 67° during the year. Adding to these zone 64°, which was printed in 1899, the measures of 268 plates out of 1149 covering 586 square degrees out of 2087, or about one quarter of the whole, is now through the press. It may be of interest to notice that these measures are printed in 336 pages of the size adopted in the Greenwich volumes.

The counting of the stars on the chart plates which was begun last year has been continued, and Zones 65° and 66° are completed, and about one quarter of Zone +67°.

The following table gives the number of stars in the three zones obtained with exposures of 40^m, 6^m and 3^m, and 20^s, compared with the number given in the B.D. and the number of stars given in that work down to $9^m{\cdot}0$. The first line for each zone gives the total number of stars shown, and the second line the number of stars which are shown twice, *i.e.* on each of the overlapping series of plates.

Zone.	No. of Sq. Degrees.	Number in B.D. $9^m{\cdot}0$ and brighter.	Number in B.D. Total number.	Number shown on Photographs. Exposure 20^s.	Exposure 3^m and 6^m.	Exposure 40^m.
65°	149	762	2,005	2,476	9,245	47,080
				1,473	7,109	39,401
66°	144	611	1,744	2,157	9,503	45,333
				1,294	7,213	38,631
67°	43	193	494	494	2,67	15,335
($0^h{\cdot}0^m - 7^h{\cdot}30^m$)				306	1,932	13,058
Totals	336	1,566	4,243	5,127 3,073	21,421 16,254	107,748 91,090
Number per Square Degree		4·66	12·63	15·26 9·15	63·8 48·4	319·9 271·1

The ratios of these numbers to the number of stars given in the B.D., *i.e.* to column 4 of the above table, are

Zone.	$9^m{\cdot}0$ and brighter.	Total No. in B.D.	Exp. 20^s.	Exp. 3^m and 6^m.	Exp. 40^m
65°	·380	1	1·235	4·61	23·5
			0·735	3·55	19·7
66°	·350	1	1·237	5·45	26·0
			0·742	4·14	22·1
67°	·391	1	1·000	5·41	31·0
($0^h\ 0^m - 7^h\ 30^m$)			0·620	3·91	26·4
Means	0·374	1	1·157	5·16	26·8
			0·699	3·87	22·7

Photoheliograph.—Photographs of the Sun have been obtained on 162 days; those on 121 days were taken with the Thompson photoheliograph of 9 inches aperture, and those on the remaining 41 days—viz. between March 10 and June 17, whilst the Thompson instrument was dismounted for use in the eclipse expedition of 1900 May 28—with the Dallmeyer photoheliograph of 4 inches aperture. Of the photographs taken 350 have been selected for preservation, including 17 with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination, and six photographs of the partial eclipse of May 28. Photographs have also been received from India up to 1900 July 4, and from Mauritius up to 1900 April 10, the year ending on the latter date being represented on 362 days out of the 365 by a photograph from one or other of the three observatories.

The measures and reductions for 1899 have been completed and the results wholly passed for press. No great progress has been made with the measures and their reduction for 1900; the work having been partly laid aside in order to proceed with the new catalogue of the library. The Greenwich photographs have been measured in duplicate up to the end of 1900 March, the Indian up to the end of 1900 May, and the Mauritius photographs as far as received. The reductions for the Greenwich photographs are complete up to 1900 March 9, for the Indian to 1900 May 1, and for those from Mauritius as far as received.

The solar activity as shown in the numbers and areas of sun-spots has been very small during the past year 1900. The mean daily spotted area of the Sun for 1899, expressed as usual in millionths of the visible hemisphere, was 111, as compared with 1464 for the year of maximum, 1893, and a rough estimate for 1900 would place the corresponding area as under 80. The actual minimum must therefore be close at hand, and may be expected in the course of the present year. The area for 1889, the year of minimum in the preceding cycle, was 78.

The publication of the various longitude determinations made in the years 1888–1898 has been taken in hand. The determination Greenwich-Paris made in 1888 is printed with the exception of a few pages. The determination of the same arc made in 1892 has been re-examined, and copy for press prepared. Copy for press of the longitude determinations Greenwich-Waterville-Canso-Montreal is proceeding. As stated in the last report, arrangements have been made for a re-determination of the Paris longitude in conjunction with observers from the Paris Observatory. It is proposed to undertake this determination in 1901 October and in the spring of 1902.

An expedition to observe the solar eclipse of May 28 having been sanctioned by the Admiralty, the Astronomer Royal, Mr. Dyson, and Mr. Davidson went to Ovar in Portugal for this purpose, leaving Greenwich on May 11, and returning to Greenwich again on June 5. A preliminary account of the observations

presented at a joint meeting of the Royal and Royal Astronomical Societies is given in an appendix to *Monthly Notices*, vol. lx. It is hoped to send two observers to make observations of the forthcoming eclipse on May 18—Mr. Dyson to Sumatra, and Mr. Maunder to Mauritius.

The printing of the annual volume of *Greenwich Observations* for 1898 and of the *Second Ten-year Catalogue* is completed, and these volumes will be distributed shortly. The volume for 1899 to the end of the *Annual Star Catalogue*, and the heliographic results, are printed. As stated previously, the measures of the astrographic plates are printed as far as Dec. 67°, which is approximately one-quarter of the whole.

Good progress has been made with the re-arrangement and new card catalogue of the library. The astronomical books and periodicals and about one-quarter of the pamphlets have been arranged, and a card catalogue of them has been made. A duplicate catalogue, to be arranged alphabetically under authors' names, is being made, the original, arranged in the order of the books on the shelves, serving as a subject catalogue.

Royal Observatory, Cape of Good Hope.

The material for the steel observatory of the new Transit Circle reached the Cape in April, and its erection was completed in December. The new transit circle itself has not yet reached the Cape. It was ready for preparatory inspection in May, and Mr. Simms took the utmost care to carry out suggested alterations made from time to time by H.M. Astronomer when he was in England. The instrument was finally passed in October by H.M. Astronomer as ready to be dismounted and packed for shipment ; it is now probably on its way to the Cape.

The 24-inch photographic object-glass of the McClean equatorial was returned to Sir Howard Grubb for correction on the 31st October 1899, but it has not yet been returned by him.*

Vol. v. of the Cape *Annals*, being the third and last part of the *Cape Photographic Durchmusterung*, has been distributed.

Vol. viii. part 2 of the *Annals*, being "Heliometer Investigations on the Parallaxes of the Principal Fixed Stars of the Southern Hemisphere," has been passed through the press.

The Cape General Catalogue of 1905 stars for 1865, based on the meridian observations made under the direction of Sir Thomas Maclear, 1860 to 1870, has been distributed.

The *Annual Results of Meridian Observations*, 1866–70, have been printed and issued.

The *Annual Results of Meridian Observations*, made under

* A telegram has since been received from Sir David Gill saying that the glass has arrived safely at the Cape.

the direction of Mr. Stone, 1877, have been printed and issued ; the printing of those for 1878–79 is well advanced.

The *Annual Results*, 1896 and 1897, containing the separate meridian observations of the Astrographic Catalogue-Plate standard stars for the zone decl. −40° 0′ to −44° 0′, reduced to the equinox 1900, have been passed through the press. Similar results for 1898 for the zone decl. −44° 0′ to −48° 0′ are printed as far as R.A. $19^h\ 46^m$. The copy for press of the results for 1899, zone −48° 0′ to −52° 0′, is in the hands of the printer.

Considerable advance has been made in the preparation of a general catalogue of the standard stars for plates of the Cape astrographic zone.

The day-numbers for the year 1902 have been distributed. Those for 1903 have been printed, and will be distributed with the annual report for 1900.

The work of the transit circle has been largely devoted to very elaborate determination of the personal equation in Right Ascension as affected by the stars' magnitude. Transits were observed over the first half of the wires "without screen," and over the second half "with screen," or *vice versâ*. The whole of the results have been discussed. The following instructive table gives some of them :—

Corrections depending on Magnitude to be applied to the Clock Times of Transits by the different Cape Meridian Observers.

Star's decl. 0° to ± 10°.

Magnitude.	Pett. s	Cox. s	Power. s	Pead. s	Woodgate. s	Cochrane. s
0	0·000	0·000	0·000	+0·058	+0·019	+0·032
1	·000	·000	·000	+ ·042	+ ·015	+ ·025
2	·000	·000	·000	+ ·026	+ ·011	+ ·017
3	·000	·000	·000	+ ·013	+ ·006	+ ·009
4	·000	·000	·000	·000	·000	·000
5	− ·009	− ·003	− ·004	− ·011	− ·006	− ·010
6	− ·026	− ·009	− ·012	− ·022	− ·013	− ·021
7	− ·051	− ·017	− ·025	− ·031	− ·021	− ·032
8	− ·085	− ·027	− ·041	− ·038	− ·029	− ·044
9	− ·127	− ·039	− ·062	− ·045	− ·038	− ·058
10	− ·176	− ·053	− ·087	− ·050	− ·047	− ·071

These corrections were obtained by independent discussions of observations in which the absorption of light by the screen corresponded to 1·8 and 3·6 magnitudes. The results given independently by both screens agreed satisfactorily. They show that whilst there is considerable range in magnitude personality for different observers, yet *every* one of the observers records the time of transit of faint stars later than that of bright stars, and

that, as a rule, this personality is greater for a given difference of magnitude in the case of faint stars than in that of the brighter stars.

A curious fact is that the difference of personality remains nearly the same for stars of very different declination. Thus, for the mean of six observers we have :—

From Recent Results.

Star's Magnitude.	Decl. 0° to ±10°.	Decl. −40° to −52°.	Originally given for the 1890 Catalogue, p. xliv.
	s	s	s
1	+0·014	+0·023	+0·042
2	+ ·009	+ ·014	+ ·028
3	+ ·005	+ ·006	+ ·014
4	·000	·000	·000
5	− ·007	− ·008	− ·014
6	− ·017	− ·018	− ·028
7	− ·030	− ·029	− ·042
8	− ·044	− ·042	− ·056
9	− ·061	− ·056	− ·070
10	− ·080	− ·072	...

The latest results should be adopted for the 1890 catalogue, instead of those given at p. xliv. of the work in question. It will be observed that the difference is mainly in corrections to the brighter stars, which were, in fact, not strongly determined in the previous operations.

The results of these investigations are being employed in the formation of the General Catalogue of 8556 standard stars of the astrographic plates.

The general work of the transit circle has been confined to observations of the stars of the new working list which is described in the last report. The observations made with the transit circle during the year have been :—

Transits for personality depending on magnitude ...	4204
Observations for R.A....	3465
Determinations of Z.D.	2824
„ „ Collimation	78
„ „ Level	177
„ „ Azimuth	202
„ „ Run	147
„ „ Nadir	148
„ „ Flexure	19

The reductions of the meridian observations to apparent R.A. and declination are complete to December 31, but in consequence

of the absence of two computers at the front, the star reductions to mean place are only partly computed and are not yet applied.

Observations of 78 separate phenomena of occultations of stars by the Moon were obtained as follows :—

	DB.	DD.	RB.	RD.	Total.
Predicted by the N. A. Office	0	17	0	17	34
Other occultations	0	40	0	4	44
Total number of separate phenomena					78

Of these 20 were observed by two observers,

5 „ „ three „

and 1 „ „ four „

Giacobini's comet was observed on four nights with the McClean telescope. Comets Brorsen and Finlay were searched for on three and four nights respectively, but were not seen.

In searching for Brorsen's Comet Mr. Lunt noted five previously unrecorded nebulæ on the region covered by the astrographic plate ($-47°$, $22^h\ 5^m$), but they are not shown on any photographic plate yet taken.

As the 24-inch photographic object-glass of the McClean telescope has been with Sir Howard Grubb in Dublin during the whole year, the 18-inch visual telescope has been employed in the measurement of double stars. Without making the discovery of double stars a matter of special research Mr. Innes has detected 31 previously unrecorded pairs, of which the following are naked-eye stars :—

	Mag.	Mag. of Comes.	Distance. ″		Mag.	Mag. of Comes.	Distance. ″
β Crucis	1·7	11·5	44	Lac 8625	5·9	...	0·3
Lac 9112	5·4	14·5	41	P. V. 122	5·9	12·0	20 0
Lac 3811	5·4	12·0	18·2	θ Pictoris	6·3	...	0·43
Lac 6277	5·4	13·0	5·5	Lac 5589	6·5	...	0·3
π_2 Gruis	5·8	12·5	4·7				

Fourteen of the remainder are under 5″ distance and the others are distant *comites* to stars between 6·5 and 8·0 mag. Mr. Innes has also detected thirteen unrecorded double stars with the 7-inch equatorial, of which 8 are under 2″ in distance. Six unrecorded double stars have been found by Messrs. Cox and Pead with the transit circle and two on the astrographic plates.

With the Repsold micrometer attached to the 18-inch visual telescope of the McClean equatorial, 816 measures of distance, and 860 measures of position angle of 430 different double stars have been made. Each measure is the mean of at least four pointings. Of these measures 228 have been made by Mr. Lunt and 588 by Mr. Innes. The stars selected for measurement have

been, as a rule, pairs which were never measured before, or which have not been observed since Herschel's expedition to the Cape. Of these, 70 pairs are under 1″ distance and 56 between 1″ and 2″. A considerable amount of attention has been devoted to observations of *α Centauri* as a double star.

Regular observations of all oppositions of major planets with the heliometer have been continued ; the following were secured in 1900 :—

	No. of Observations.
Opposition of *Jupiter*	53
„ *Saturn*	40
„ *Uranus*	44
„ *Neptune*	66

The triangulation of the *Jupiter* comparison stars for 1898 has been completed ; the work involved observations of 86 distances in the triangulation and 26 standards in 1900, in addition to 36 distances and 17 standards measured in 1899. The triangulation of the comparison stars for *Uranus* 1897–1900 and *Saturn* 1898 is nearly completed ; 106 distances and 36 standards in this triangulation having been observed in 1900. The triangulation of the comparison stars for *Neptune* 1897–1900 is also nearly completed ; 27 distances and 11 standards in this triangulation were observed in 1900.

Three sets of heliometer observations of the conjunction of *Jupiter* and *β Scorpii* were made. The triangulation of the circumpolar area has been completed by the observation of 83 distances and 26 standards during 1900, in addition to 513 distances and 168 standards observed in former years.

The partial eclipse of the Sun on November 22 (civil time) was observed with the heliometer, 88 pointings were made of the distances of the cusps. Twenty-six photographs of the eclipse were made with the photo-heliograph.

During the year the reduction of the heliometer observations has been confined to the distances measured in the polar triangulation ; the reduction of the instrumental distances is complete ; the computations of the corresponding tabular distances from the meridian observations and the formation of the equations of condition for the discussion of the results are also finished, but the normal equations have not yet been formed.

H.M. Astronomer has gratefully to acknowledge very valuable series of observations of comparison stars from the principal meridian observatories.

The long computations connected with the discussion of the heliometer observations of *Jupiter's* satellites are nearly completed.

With the Astrographic Telescope the following work has been accomplished : —

	No. of Plates.	No. of Exposures.	Duration of each Exposure.
Triple image Chart plates, passed * ...	103	309	30^m
„ „ rejected ...	44	132	30^m
Revision Catalogue plates	172	516	6^m, 3^m, 20^s
Iris plates †	7	42	3^m to 1^m
Galactic comparison plates	6	12	10^m
Various (focal adjustments, &c.) ...	14	...	...
	346	1011	

With reference to the revision Catalogue plates, it is intended, as mentioned in the last report, to repeat the whole series in order to bring the epoch at which the plates are taken more nearly to that at which the standard stars were observed on the meridian. The question is now under consideration whether the standard stars, at least, should not be measured on both sets of plates. The new measuring machine, devised by H.M. Astronomer and constructed by Messrs. Repsold, has continued to give the greatest satisfaction. A second machine of the same type was brought into use early in 1900, but the training of additional observers and the loss of two trained observers has limited the expected output of work. During the year, 124 catalogue plates of the Cape zone, containing 71,655 stars, have been measured in both coordinates, in each of the two reversed positions of the plate; all the standard stars on each plate have been measured by both observers. When either coordinate of any star, as measured in one position of the plate, differs by $0''{\cdot}6$ from the corresponding coordinate resulting from the measure in the reversed position of the plate, the observations in both positions are repeated. The measures of 248 plates, besides two plates rejected after measurement, have now been converted into rectangular coordinates in arc, and the results for 163 plates have been examined and prepared for press.

This enumeration includes the measurement of nine circumpolar plates containing 2095 stars. The Cape has taken over from Melbourne the observation and measurement of the circumpolar zone to 2° S.P.D., because the data for this work will be greatly strengthened by the results of the heliometer triangulation of the circumpolar area. An independent determination of the stars of this area has been undertaken by Professor Jacoby from an earlier series of plates.

The revision of Kapteyn's C.P.D. lists mentioned in previous reports has now been practically completed by Mr. Innes, and the results are ready for press. The following new variable stars have been detected in the course of this year's work :—

* The total number of triple image Chart plates now taken and passed is 362.

† Completion of series taken July to December, 1899. See last report.

	1875. h m	° ′	Range.	Period. d
C.Z. VII. 2258	7 31·9	−73 7	9·1 to inv.	400 ±
„ IX. 3759	9 48·6	−53 36	9·3 to inv.	360 ±
Gilliss P.Z. 9192	13 9·5	−83 34	7·7 to inv.	273 ±
„ „ 9628	13 43·7	−77 11	8·6 to inv.	...

Besides these, several other suspected and known variable stars are under observation.

A list of all stars in the C.P.D. marked ? or X has been prepared, and considerable progress has been made in examining the objects of this list. Stars marked ? by Kapteyn are those of which he considered the existence as not satisfactorily proved; so far as the revision goes, about three-fourths of them are found actually to exist. The stars marked X (image of star somewhat nebulous) are generally found to be very minute double stars, in no case showing any decided nebulosity.

The weather on November 14, 15, 16, and 17 was persistently cloudy; no observations of *Leonid* meteors could be made.

In the Physical Laboratory Mr. Lunt has been occupied with investigations on the spectra of Oxygen, Silicon, Aluminium, Boron, and Sulphur.

The records of the seismograph have been forwarded monthly to Professor Milne during the year.

The Geodetic Survey of Rhodesia has been pushed forward as steadily as circumstances would permit. Mr. A. Simms with his assistants, Messrs. Heatlie and Antrobus, reached Beira on March 31, after having spent three months at the Cape during the season when the rains rendered transport near the Zambesi impossible. A base line near Salisbury has been measured with the Jäderin apparatus and the points selected and beaconed for its connection with the chain and many stations were occupied for observations of angles. To complete the whole work to the Zambesi there remain the measurement of the angles at eleven points already beaconed, the selection of six to eight additional stations, and the measurement of angles at these new stations. This work will probably be completed in July. Mr. Antrobus is now on his way to the Cape bringing for comparison the Jäderin wires used in measuring the Salisbury base.

The operations of the Anglo-German Boundary Survey are in steady progress, but have been delayed by the exceptional difficulties of the country, want of water, &c. A base has been measured with Jäderin wires near the northern point of the arc (lat. 22° S.), and Major Laffan and Lieutenant Wettstein expect to return to the Cape about August 1 next, in order to obtain the data from their observations for beaconing the actual boundary.

The printing of the re-reduction of Bailey's Survey mentioned in last report is still incomplete, owing to delays on the part of the Cape printers. The work will now soon be ready for distribution.

The meteorological observations made during 1900 have been communicated to the Cape Meteorological Commission.

Two computers, also the optical fitter and the carpenter, were called out as members of the Cape Volunteer Artillery for active service at the seat of war in October 1899, and have been absent from the Observatory during the whole of the year 1900. Mr. C. Ray Woods and Mr. S. Goodman retired from the Observatory service on November 30 and September 30 respectively; their places are not yet filled, and the work of the Observatory has necessarily suffered by the absence of so large a part of its staff.

H.M. Astronomer was absent on leave from April 8 until November 20, Mr. S. S. Hough remaining in charge. During his visit to Europe H.M. Astronomer attended the meetings of the Permanent Committee of the Astrographic Congress and of the International Geodetic Association, which were held at Paris in July and September respectively; he was also present, as a delegate of the Cape Colony, at the meetings held at Burlington House for organisation of the International Catalogue of Scientific Literature. He was also much occupied in England in connection with the great African Geodetic Arc, the inspection of the new transit circle, and the details of plans and experiments in connection with the construction of a sidereal clock of entirely new design which is under construction by the Cambridge Scientific Instrument Company for use with the new transit circle.

Royal Observatory, Edinburgh.

The grounds and Observatory buildings have been maintained in good order by H.M. Office of Works, Edinburgh. The painting of the interior of the buildings, which was postponed after their erection, to allow the plaster work to become perfectly dry, was commenced in the end of October, and was approaching completion at the end of the year. With the exception of the injury to the east dome, referred to below, very little damage, either to the residences or the Observatory, resulted from the great storm of December 20–21. The plantations of young trees also fortunately suffered little, considering the violence of the gale.

It is with much regret the decease is here recorded of the late Dr. Charles Piazzi-Smyth, ex-Astronomer-Royal for Scotland and Emeritus Professor of Practical Astronomy in the University of Edinburgh. He died on February 21 at Clova, Ripon, Yorkshire, in the 81st year of his age. Amongst the obituary notices in the present number of this publication will be found an account of his life and astronomical work.

The time services for the cities of Edinburgh and Dundee have been carried on as in former years, the signals by time-ball and gun-fire in Edinburgh and by gun-fire in Dundee being

controlled by the Molyneux mean-time clock of this Observatory. The ball was not raised on 1900 January 26 on account of the severity of the gale. There was no gun-fire at Edinburgh on May 11 owing to a derangement of the magnets of the controlled clock at the Castle, and again on June 12, the electric contacts having been injured during a thunderstorm. From December 21 to 25 the city time service was completely cut out of connection with the Observatory, the wires having been broken down by a tree falling across them during the violent gale of the night of December 20. Only one incorrect signal was given during the year, the Edinburgh gun being fired two seconds slow on December 17, owing to a displacement of the seconds hand of the Castle controlled clock. With these exceptions the time service has worked satisfactorily.

The observations with the Troughton & Simms Meridian Circle were made throughout the year by Dr. Halm and Mr. Clark. The measurements of Sir David Gill's 2798 zodiacal stars were continued, on all favourable occasions, according to the programme adopted in the previous year. The errors of the instrument were controlled at short intervals by means of the collimators and observations of *α Ursæ Minoris* in both culminations, and every opportunity was taken for determining corrections to the standard clock used for the time service of the Observatory and city. In the summer of this year the Observatory received, through the kindness of Lord McLaren, the loan of his 4-inch heliometer for the purpose of measuring the planet *Eros* at the time of its opposition. Dr. Halm, assisted by the Observatory engineer, Mr. McPherson, mounted and adjusted the instrument in the hut previously occupied by the 12-inch Browning reflector. Throughout the autumn all the clear nights available were taken advantage of by Dr. Halm to redetermine the angular value of the scale divisions by observations of the *Perseus* zone and three stars in the *Pleiades*. The faintness of the planet during this appearance, however, did not allow of more than two measurements with this instrument being obtained—viz. on December 26 and December 29. On the other hand 51 observations of the planet at considerable hour-angles were secured with the 15-inch refractor by Dr. Halm, during the time from October 21 to December 12, while Mr. Heath measured the planet with the same instrument near the meridian seven times, and made a number of measures of a few other minor planets during the course of the year. Unfortunately the accident to the dome, referred to, on the night of December 20 put a sudden end to these observations just at the time of the closest proximity of *Eros* to the Earth. Four measures of the position of Comet 1900 *b* were also made by Mr. Heath and Mr. Clark with the 15-inch refractor.

Some observations of *Eros* were also made with the Meridian Circle, nine by Mr. Clark and four by Dr. Halm. In spite of the large aperture of the instrument—8 inches—only one

of these observations could be made with the bright field illumination.

The reduction of the Edinburgh meridian observations made between 1834 and 1845 has been continued by Dr. Halm and Mr. Clark, who received valuable assistance in this work from Mr. Neustadt, the temporary computer. The work is now in process of arrangement for the press.

At the invitation of the Joint Eclipse Committee of the Royal Society and Royal Astronomical Society, Professor Copeland undertook to organise an expedition to Spain to observe the total eclipse of the Sun of May 28. A preliminary report on this expedition will be found at p. [49] of the Appendix to vol. lx. of the *Monthly Notices*.

The meteorological observations have been made by the staff of the Observatory on the same lines as in former years. The bi-daily readings of the barometer, wet and dry bulb thermometers, estimates of wind and cloud, and daily readings of the shaded and exposed maximum and minimum thermometers, have been continuous throughout the year. A monthly copy of these observations has, as usual, been supplied to the Secretary of the Scottish Meteorological Society for the use of the Registrar-General for Scotland, and the monthly means have been published in the Registrar's returns. The Robinson Anemometer and King's Barograph have also been in operation without interruption, and the weekly readings of the Rock thermometers at Calton Hill have been continued. A Campbell-Stokes sunshine recorder was mounted in December, and arrangements made for commencing observation of this important meteorological element on 1901 January 1.

The two bifilar pendulums and their photographic-recording apparatus have been in operation throughout the year. A few slight tremors have been recorded, but they are not of an interesting character. At the request of the Seismological Committee of the British Association, a Milne Seismograph was erected in the beginning of December, and was put into operation on the 5th of that month. The instrument, which is of the horizontal boom type, is placed in the basement of the Observatory buildings, the pier on which the pillar stands being built of granite blocks bedded in cement on the porphyritic rock of which Blackford Hill is composed. The first record of an earthquake with this instrument was found on the photographic paper for the morning of December 25, in agreement with similar records obtained at Shide, Kew, and San Fernando. The disturbance began at $5^h\ 16^m$ a.m. and ended at $6^h\ 28^m$ a.m. ; the maximum was at $5^h\ 56^m$, and had an amplitude on the photographic paper of about 4 mm.

The violent gale which passed over Scotland on the night of December 20–21 was unfortunately the cause of great damage to the east dome. It was found that by the fracture of three of the brackets holding the lateral guiding wheels the dome was

forced horizontally off the wheels of the live ring. The accident was at once notified to the Surveyor of H.M. Office of Works, Edinburgh, by whom immediate steps were taken to have the repairs executed by the maker of the dome, Sir Howard Grubb. On December 31 it was successfully replaced on the live ring under the superintendence of Mr. Rudolf Grubb. At the date of this report the repairs have not been completed, but all necessary precautions have been taken to prevent further damage. This storm was of altogether exceptional violence, and an exceedingly interesting record of it has been secured on the Robinson anemograph. For several days preceding the 20th the weather had been of a stormy character, high winds prevailing. The storm appears to have culminated about midnight of the 20th, the velocity for the hour 11 p.m. to midnight having been not less than 93 miles.

The *Leonid* meteors were expected on the nights of November 14, 15, and 16, and arrangements were made for observing them on each of these nights. The last two nights were hopelessly cloudy, but the 14th was fairly clear till the early morning. Nine meteors were seen having all the characteristics of *Leonids*, with this exception, that they did not radiate exactly from the predicted point. Their apparent paths were carefully plotted by Mr. Clark on a specially prepared map, and it was found that four of the trails radiated from the same point—viz. R.A. $9^h\ 49^m$; decl. $+29°{\cdot}2$. The other five trails radiated from a very small area whose centre was situated at R.A. $10^h\ 3^m$; decl. $+32°{\cdot}2$. These meteors may perhaps be considered as belonging to the *Clino-Leonids*.

Some trial photographs with the Grubb 24-inch reflector were made in the end of the year by Mr. Heath, to test the regularity of the driving clock and the adjustments of the instrument. For this purpose the flat had to be resilvered. The clock was found to work admirably, and the careful adjustment of the instrument was taken in hand.

A summer course and a winter course of lectures in astronomy were delivered by Professor Copeland to the astronomy class in the University of Edinburgh.

Armagh Observatory.

The photographic micrometer referred to in last year's report has been employed in measuring some plates of the *Pleiades* and a plate of the spiral nebula M 33, kindly lent by Dr. Roberts. A second plate of the latter object has recently been received. The errors of the micrometer screw have been fully investigated. After many experiments it was found necessary, for the purpose of determining the division errors of the glass scale, to cut the plate in two lengthways, so that the divisions would be on the edge of the glass, along which an auxiliary scale could be made

to slide. The scale and its stage were therefore sent to Messrs. Troughton and Simms early in November for alteration.

Towards the end of the year a great deal of time was spent on the examination of the reductions of about 160 stars of the Armagh Catalogue in order to clear up errors pointed out by Dr. Ristenpart. The results of this work will shortly be communicated to the Society.

The meteorological work, which includes tabulation of the records of the anemograph and self-recording rain-gauge, has been continued on the same lines as since 1884.

Cambridge Observatory.

Meridian Circle.—In consequence of the unfavourable weather, observations were made with this instrument on 91 nights only during the year. Frequent observations of standard stars, especially *Polaris*, were taken by day, for time and instrumental correction.

All the faint stars in the Cambridge portion of the catalogue of the *Astronomische Gesellschaft*, of which the places there given depend on a single observation, have been re-observed several times, the reductions completed, the places reduced to Epoch 1875·0, and the results arranged in order of right ascension.

The work of observing Sir David Gill's list of Heliometer Comparison Stars, begun in 1899 March, was completed during the early part of the year. To this end 459 observations were taken. These are all reduced to mean equinox at the beginning of the year, and the results tabulated.

The list of Harrow Occultation Stars, furnished by Colonel Tupman, with the exception of a very few difficult faint ones, has been observed ; the resulting apparent places are all reduced to mean equinox at the beginning of the year, and the mean places tabulated.

At present the instrument is chiefly used for the observation of stars comprised in Sir David Gill's catalogue of 2798 zodiacal stars for the Epoch 1900. Of these, 1127 observations have been taken during the latter part of the year, and, besides these, 157 observations of zodiacal stars from other catalogues. These are all reduced to apparent right ascension and apparent declination. The work of reducing them to mean equinox at the beginning of the year has been begun.

As an essential part of the work, there have also been made 612 observations of standard stars—chiefly *Nautical Almanac*—for clock error ; and for instrumental deviation 67 observations of *Polaris* at the upper transit and 79 at the lower, and 62 observations of other close circumpolar stars. The observations of *Polaris* have also been utilised in making a fresh determination of the intervals of the wires.

The nadir point, level, and line of collimation have been regularly observed, and the constants for instrumental correction have been obtained from 137 equations.

After each observation for level and line of collimation, the transit wires have been always adjusted so as to leave the observations practically free from error of collimation and from the effect of diurnal aberration.

Toward the close of the year a request came from Dr. Auwers that all the Cambridge transit observations made during the years 1846–1869 should be reduced to Epoch 1855·0, and formed into a catalogue. He also requested that a preliminary list of the stars that had been observed should be sent to him as soon as possible. This preliminary list is in course of preparation, and stars observed during these years of R.A. 0^h-10^h are now arranged in order of right ascension.

Sheepshanks Photographic Equatorial.—At the date of the last report considerable alterations in and additions to the instrument had just been completed. They were designed to close in the elbow-joint and prevent the free access of air to the tube and mirror. Definition has been considerably improved by the alterations.

In March the new guiding apparatus and plate-carriers were delivered. Their design is based upon Dr. Common's form of apparatus, with some elaboration of detail. The screws which move the plate-holder along rectangular slides have divided heads ; the guiding eyepiece has motion in two coordinates with divided scales ; the eyepiece is a low-power compound microscope, so that the eye is at a convenient distance—about four inches—behind the plane of the plate, and the observer's face is not pressed flat against the slides, as it would be if a common eyepiece of half-inch focal length were used. A large finding eyepiece has been made to fit on in place of the plate-carrier. It has a power of about 25, and a field of view rather more than a degree in diameter. The eyepiece contains a network of silver wires, which can be illuminated at pleasure, and by means of which the field to be photographed is properly centred, and a finding star selected and brought into the finding eyepiece.

On 1900 May 28 sixteen plates were obtained of the partial Solar Eclipse, with two exposures upon each. They have not yet been measured.

It had been recognised for some time that the figure of the plane mirror was not quite perfect, and, in May, Dr. Common very kindly undertook to refigure it. The mirror was dismounted and returned to Ealing on May 31, and on July 9 another mirror of the same size was received from Dr. Common in place of the old one, which proved to be slightly convex. During August and September the adjustments of the instrument were completely revised.

A first photograph of *Eros* was obtained on September 29 ; and since then the instrument has been devoted entirely to the

observation of the planet. A few days' work showed that in most respects the new guiding apparatus and accessories were completely successful, and the work has proceeded with but few instrumental troubles up to the present time. But the weather has been extremely unfavourable for diurnal parallax work.

Summary of Weather at Cambridge, 1900 *October to December.*

	Oct.	Nov.	Dec.
Clear all night...	2	1	1
Clear most of the night	6	2	2
Clear for an hour or two	14	8	12
Completely cloudy	9	19	16

In spite of the greatest endeavours to take advantage of every hour of clear sky, there were only seven nights between October 1 and December 31 on which it was possible to obtain a parallactic displacement of *Eros* greater than $25''$. The greater part of the observations form incomplete series, useless for the diurnal method, but available for comparison with simultaneous observations at a distant station.

The whole of the exposures obtained up to December 31 have been carefully examined in the measuring machine, and classified according to the character of the image of the planet. The examination gave—

	Oct.	Nov.	Dec.
Measurable Images.			
Good	3	60	46
Fair	26	52	41
Faint	57	35	28
Very faint	37	18	12
Images Rejected.			
Too faint	55	12	13
Defective	30	24	19
Totals	208	201	159

Grand total, 568.

Of the images rejected as defective, the greater number showed no visible defect; but the observer noted that the exposures were perhaps interrupted by cloud. It has been judged best to reject without exception all images liable to suspicion on this account.

The full observing programme was to obtain four images of the planet per hour between the hour angles 6^h E. and W. The construction of the instrument prevents observation in greater hour angles. During two exposures of each series the planet was followed; during the other two the stars. The corrections to the driving required to follow the planet in R.A.

were obtained by altering the weights upon the dish of the pendulum. The motion in declination was obtained by turning slowly and continuously the divided head of the screw which moves the plate-holder in declination, completing a turn through one division in a calculated number of seconds. This method worked very satisfactorily.

The measuring machine, which has been made by the Cambridge Scientific Instrument Company, was completed at the end of November. A preliminary examination shows that the errors of screws and scales are extremely small, and that the settings are of a high order of accuracy. A description of the machine will shortly be communicated to the Society.

The Newall Telescope, Cambridge Observatory.

The Newall Telescope was used for observations on eighty-eight nights in the course of the year 1900.

During the greater part of the year the instrument was used in connection with the large four-prism spectrograph referred to in last year's report. The scale of the spectra obtained is approximately six tenth-metres per millimetre, and hence only the brighter stars can be examined with the instrument. Ninety-seven photographs of stellar spectra, nearly all involving long exposures, were obtained; many others have been rejected on account of insufficient exposure. Sixty-one photographs have been measured for determination of velocity in the line of sight and for other investigations not yet completed.

Some preliminary results for the case of *α Aurigæ* were communicated to the Society in March (*Monthly Notices*, lx. p. 418). Variable velocity has been detected in *α Persei*, and some of the results of the measurements were communicated to the Society in November (*Monthly Notices*, lxi. p. 12).

The four-prism spectrograph was dismounted at the end of April and sent to Algiers for use during the eclipse of the Sun on May 28: it was not received back again until the end of July. During this interval a camera was mounted on the eye-end of the equatorial in order that certain double stars might be photographed with enlarged images. But as there were only eleven nights in May, June, and July on which observations could be made, but little progress was made with this work.

The new micrometer for measuring spectrum photographs—Zeiss's Comparator—has been in use during a great part of the year. The silver scale is 100 mm. long, and this interval is divided into 500 parts. The errors of the division marks and of the micrometer screws were carefully investigated in July and August, and the corrections to be applied for each of the 500 marks were determined. This investigation of the scale was laborious, involving more than 6000 settings of the micrometer. The results are eminently satisfactory.

Dunsink Observatory.

Observation of the stars included in Sir David Gill's list of 2798 zodiacal stars has been continued by Mr. Martin throughout the year. The total number of meridian circle observations is 4915. These consist of 2036 in R.A. of the zodiacal stars, 287 for determining the error of the Dent sidereal clock, 65 for collimation, 72 for level, 61 for azimuth, 2036 observations of declination of the zodiacal stars, 270 for the equator point of the circle, and 65 for the nadir point. The error of runs of the microscopes was determined 23 times. The observations have been reduced to apparent place up to December 13.

The Ninth Part of the *Astronomical Observations and Researches made at Dunsink* was distributed in October. It contains the results of meridian circle observations of 321 stars—stars of reference for clusters and heliometer comparison stars observed at Sir David Gill's request. The average number of complete observations for each star is about four.

As far as the unfavourable weather allowed, work has been continued with the Roberts' photographic reflector in photographing star clusters, and, since September 24, in taking *Eros* plates. The season here was the worst for many years. During four months in summer only seven nights were fit even for meridian circle observations.

During the eclipse, on May 28, Mr. Martin observed the times of contact with the South equatorial and the march of temperature of two radiation thermometers. His results were communicated to the Royal Dublin Society, and were published in the *Proceedings* of that body. The director accompanied the eclipse expedition, fitted out by the Royal Irish Academy and the Royal Dublin Society, to Plasencia, in Spain, and obtained photographs of the corona with a 4-inch lens of 20-foot focus. The preliminary results of the expedition will shortly be communicated to the two Societies.

A large number of visitors throughout the year utilised the opportunity of observing with the South equatorial on the open nights—the first Saturday in every month.

The time service to Dublin has been continued as usual.

Durham Observatory.

The Almucantar, of which a description was published in the *Monthly Notices* of June last, has been in use by Professor Sampson and Mr. F. C. H. Carpenter on most favourable nights between July and November. An amount of useful experience has been gained, and the results are generally satisfactory ; but the failure to obtain a chronograph, now long overdue from a firm of instrument makers, has given them a provisional character, and has prevented any conclusive work from being done.

The discussion of the Harvard eclipses of *Jupiter's* satellites has proceeded satisfactorily. One hundred and nineteen eclipses of III have been reduced, charted, and measured, and provisional values of the corrections to Damoiseau's elements have been deduced from them. An entirely independent discussion of the ordinary observations of III, extending over sixty years, has also been made, and the corrections thence deduced show a most satisfactory agreement with those found from the Harvard eclipses as far as the equations of conjunction are concerned. Meteorological observations have been carried out as heretofore.

Glasgow Observatory.

The transit circle was used during the year for the observations of the star *B.D.* 89° 37′ and of α and λ *Ursæ Minoris*, in continuation of the work which was begun four years ago. There were only 39 nights during the year on which faint objects, in the vicinity of the pole, could be observed for several hours, and these nights were, with the exception of three, devoted to these measurements. The reductions are up to date.

In the last three months a fresh attempt was made to photograph the spectrum of the *Andromeda* nebula by means of the slit spectroscope of the Breadalbane reflector. Although every possible opportunity was seized, only 33 hours of exposure could be secured till the end of the year, and the plate will probably again be lost. Long exposures were also given to the spectrum of the *Orion* nebula during the earlier part of the year.

The director, aided by three computers, has devoted a great deal of his time to the working up of the meteorological records which have accumulated during 33 years. The daily and yearly temperature curves and sunshine curves were satisfactorily represented by formulæ based on physical considerations.

Time observations were taken on 135 nights, and the meteorological work has been carried on as in former years.

Liverpool Observatory.

No material alteration has been made in the routine work of the Observatory, and the instruments remain much in the condition mentioned in the last report. A Richard self-recording thermograph of the largest size was mounted last summer. This instrument completes the apparatus for the automatic registration of meteorological elements. A second bifilar pendulum on the principle suggested by Professor G. H. Darwin has been mounted in the basement, the plane of whose registration is turned 90° in azimuth from the one earlier mounted and mentioned in the last annual report. The results derived have been up to the present very disappointing, and owing to the bursting of a water-pipe in

the cellar they have had to be discontinued. Within the last few weeks a Milne seismometer has been placed in the same cellar (under arrangements made with the Earthquake Committee of the British Association), with the view of determining the character of the geological formation best adapted for the record of earthquake disturbance. It is proposed to compare the results of the daily waves shown by this instrument with those obtained by the Darwin bifilar. The Milne seismometer has been in operation only since the beginning of the year.

The alteration made in the method of firing the one o'clock gun, to which allusion was made in the last report, has proved quite satisfactory. There has been no failure of the signal during the year, and only on a very few occasions has the error in time amounted to half a second. The transit instrument has performed satisfactorily and has been employed in the same manner as last year. Owing to bad weather and the small altitude of the planets *Jupiter* and *Saturn*, the measurement of diameter has been discontinued. Some observations of the diameter of *Venus* with various micrometers have been made. Such cometary observations as have been made will, as usual, be submitted to the Society for publication. A continuous look-out was kept for the *Leonids* at the time of their possible reappearance. The sky was generally overcast on the three nights most suitable for observation, and no results of any value were obtained. The reduction of an occultation of the *Pleiades* and of stars at times of two recent eclipses of the Moon has been made by Mr. Henry Plummer, and the results have been published by the Society.

Radcliffe Observatory, Oxford.

This year a determined effort has been made to overtake the arrears of reduction and publication to which the present Director of the Observatory succeeded, and for this purpose systematic observations have been interrupted during the greater part of the year.

During the year the Meteorological Results from 1892 to 1899 inclusive have been prepared for press, and are now in the printer's hands. They will shortly be published as the forty-eighth volume of the *Radcliffe Observations*.

The reductions of the astronomical observations, which were also very much in arrears, have been vigorously pushed forward, and are now in a fairly satisfactory condition.

For the Right Ascensions, the means of all transits have been taken, and the reduction to the centre wire completed to 1900 July. The instrumental errors have been determined, and the corrections entered to 1899 November 17, and the corrections applied to 1896 March 2.

All the observations of zenith distance have been entered to the end of 1900, and, with the exception of the planetary observations, are completely reduced to 1898 December 6.

No further progress has been possible in the reduction of the old observations of Dr. Hornsby and his successors, between the years 1774 and 1838, which were mentioned in last year's Report, and of which some specimens were published in the *Monthly Notices* for 1900 January. An application was made to the Government Grant Committee of the Royal Society for a grant of money to enable this work to be undertaken; but the application was unsuccessful, being postponed on account of the large sum (2000*l.*) which will be needed for its complete accomplishment. The period, 1774, at which these observations begin, brings us back to within twelve years of Bradley's time, while, in point of accuracy, these observations seem to be quite equal to his.

It will be a serious loss to astronomical science if these valuable old observations are, for want of funds, allowed to perish unused.

In the early part of the year a good deal of time was devoted to an examination of the new micrometer and breech-piece of the transit-circle mentioned in last Report. In its original form, no accurate results could be obtained with this micrometer. Certain alterations and improvements were found to be necessary, and these were effected by Mr. Simms in February and April. It is still necessary, however, to be careful in the use of this instrument.

In September, the sidereal clock was sent to Messrs. E. Dent for the insertion of a new contact wheel, the previous one supplied by them having been found to be slightly eccentric. This alteration has much improved the running of the clock and the registration of the clock beats on the chronograph.

During the year an attempt was made to determine the errors of the pivots of the transit-circle by means of an apparatus specially designed for that purpose. This consisted of a flat mirror of five inches diameter attached to the west pivot and rotating with it. To this was directed a fixed collimator with cross-wires in its focus. Unexpected difficulties have been met with in these experiments, and the results are not yet quite satisfactory. The experiments are still in progress.

The Barclay Equatorial has been used for observations of variable and coloured stars, for the examination of some nebulæ and clusters, for the partial eclipse of the Sun on May 28, and for the occultations of *Saturn* by the Moon, which occurred on June 13 and September 3. Some of the results of these observations have been already communicated to the Society, and published in the *Monthly Notices.*

The heliometer and Marlborough telescope were also employed for observing the eclipse of the Sun on May 28, and the occultation of *Saturn* on September 3.

The result of the watches kept at this Observatory for *Leonids* on November 13–16 has already been communicated to the Society.

The meteorological observations and automatic registrations have been maintained as usual during the year.

The five underground platinum-resistance thermometers have worked very satisfactorily. The observations obtained with these instruments during the year 1899 have been fully discussed, and the results published in the *Transactions of the Royal Society* (Vol. 195, pp. 235–258), in a memoir entitled *Underground Temperatures at Oxford in the year* 1899, *as determined by five Platinum-resistance Thermometers.*

Satisfactory progress has been made during the year with the large equatorial refracting telescope, which, as was mentioned in last Report, it has been decided to erect at this Observatory.

The 18-inch visual object-glass, which the instrument is to carry, has been finished, and the 24-inch photographic object-glass is very nearly so. The mechanical parts have all been constructed, and the instrument is now in process of erection in Sir Howard Grubb's workshop. The construction of the elevating floor is also well advanced.

At Oxford a new tower, 35 feet high and 31 feet in internal diameter, has been built; the dome of steel and *papier-mâché* has been erected, and the water laid on for the hydraulic ram.

It is hoped that the erection of the telescope at Oxford may be commenced early in the spring.

University Observatory, Oxford.

The work for the *Astrographic Catalogue* went on steadily through the first eight months of the year, but the last four months have been devoted almost entirely to work on the planet *Eros.* Hence the number of plates completely reduced during the year is smaller than usual, being 103, which brings the total to 749 plates out of the 1180 required. Besides these, about 45 plates are measured and the reductions in a forward state. It may be remarked that the zones $+25°$ $+26°$ $+27°$ are now finished. The number of measures made during the year (in addition to those on *Eros* plates) was 63,000.

With regard to *Eros*, 85 plates, containing in all 553 exposures, have been taken, the exposures being almost always near the extremes of the parallactic range. The usual exposures have been 1^m, 2^m, or 3^m, though others have been made by way of experiment from 10^s to 10^m. On December 28, when the parallax was $27''{\cdot}9$, 54 exposures were made between hour angles $1^h\ 38^m$ east and $7^h\ 58^m$ west; but the weather near the time of greatest parallax was not generally good.

Standard coordinates have been computed for the stars on these plates which are in the catalogues of the *Astronomische Gesellschaft* (Bonn, Harvard, Leiden, &c.), involving 1184 positions up to December 22. These stars and the planet have been measured in a provisional manner (which may be supple-

mented later) on 27 plates, involving 12,665 measures. The positions of the planet derived from five of these plates were published in November (*Monthly Notices*, vol. lxi. p. 16).

A good deal of work in the measurement of eclipse photographs has been done by the director, and some of it is ready for publication. The law of coronal brightness seems to be that of the inverse sixth power of the distance from Sun's *centre*.

The director observed the eclipse of May last at the Algiers Observatory, as one of the observers sent out by the Joint Permanent Eclipse Committee.

A new dome was supplied for the Astrographic Equatorial by Messrs. T. Cooke & Sons, during the spring, with a wide shutter opening ($4\frac{1}{2}$ feet to $7\frac{1}{2}$ feet) which has been an immense convenience. The *Eros* work could scarcely have been done at all with the old dome. During the four months when the dome was being erected, and the supply of plates to be measured ran short, a good deal of experimental work was done in comparing our measures with the Bonn *Durchmusterung* by the method indicated in *Monthly Notices*, lx. p. 427. It seems, however, doubtful whether this comparison is profitable, as the D.M. places are found to be too rough to give any results of value.

Temple Observatory, Rugby.

The usual educational work has been carried on as before, the early part of each fine evening being given up to boys. There have been special classes during the October term for instruction in the use of the instruments. The measurement of double stars has been continued later in the evenings. The Observatory has suffered much in the regretted loss of Mr. Atkinson, whose health unfortunately failed.

Stonyhurst College Observatory.

The solar surface drawings number 157 on as many days. The number is smaller than usual, owing mostly to building alterations of the dome, which kept the telescope idle from April 2 to May 14. The mean spotted disc-area deduced from these drawings is 0·55, against 0·74 of last year.* It is not yet clear whether we have arrived at, or passed, the minimum epoch; and there is the same uncertainty about the minimum epoch of magnetic disturbance. Taking the extreme range of the declination magnet on each day as a measure of the magnetic disturbance on the day, the mean of these for the year is 9′·7, against 12′·9 for the preceding year. But a small spot group was sketched on September 2 and again on September 3, in latitude $-25°$ and longitude 105°; and this

* The unit being $\frac{1}{5000}$ of the visible disc.

appearance in high latitude, according to past experience, may be the forerunner of the expected revival of solar surface activity.

The work, which was commenced last year, of comparison between individual sun-spots and Earth-magnetic storms, was brought to a conclusion in September; and the results were presented to the R. A. S. in a paper read at the December meeting. This will appear in the next volume of the *Memoirs* of the Society; an abstract of the same is given in the December number of *The Observatory*. The comparisons cover the eighteen years from 1881 January to 1898 December, during which period we have a daily record of the Sun's surface in the Greenwich volumes, from photographs taken at Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

The tabulations occupied a considerable part of the past year and the early months of this year, 1900. They contain complete histories of the principal spots from first appearance to final extinction; and in this form they have been found of great service both for the comparison between sun-spots and magnetism, and for the study of characteristic differences between separate spots, and between the same spots at different ages. The latter study was undertaken by Fr. Cortie; and his conclusions are given in the May number of the *Monthly Notices*, in a paper "On the Greater Sun-spot Disturbances for the years 1881–99," and "On the Types of Sun-spot Disturbances," in a paper read at the meeting of the British Association in Bradford in September.

The tabulations of magnetic storms has also led to a special study of these independently of their connection with sun-spots. Comparative measures of their magnitude at different positions on the Earth's surface have been commenced, and fair progress has been made; but the work will need considerable time.

The watch for the *Leonids* was kept throughout the night of November 14–15, when it was mostly clear; but very few meteors were seen. The nights 12th and 13th were cloudy throughout.

During the progress of the solar eclipse of May 28 the solar prominences were measured with the spectroscope; and the time of last contact was observed satisfactorily. These were communicated to the R. A. S. in June, and are published in that number of the *Monthly Notices*.

The Grating Spectrographs of the H K region of the solar spectrum number 57. The instrument has been partly dismounted since the end of October, in order to make use of its quartz lens telescope in connection with some experiments in stellar spectrography. These experiments have occupied all the available nights of November and December. They are not yet complete; for progress is slow on account of the many photographs required, and the few clear nights. At present they promise well to be a valuable addition to the spectrographs already obtained, by a considerable extension of the spectra in the ultra-violet region.

Markree Observatory (Col. E. H. Cooper's).

During the year 1900 the Observatory has continued under the charge of Mr. F. W. Henkel, B.A., as before.

The usual meteorological observations have been regularly made and reduced, the weekly and monthly returns having been sent to the Meteorological Office, the Registrar-General at Dublin, and Mr. Symons as before. A few observations have been made with the unifilar magnetometer and the dip circle.

The partial eclipse of the Sun on May 28 was well seen and the time of last contact determined. A watch made for the *Leonids* on three nights had almost negative results, only one or two being seen on the early morning of November 17.

A few lectures were given in the early part of the year, and it is proposed to give some more should sufficient interest exist for them. Astronomy, however, is a subject not likely to be taken up by the Technical Education Committee.

Mr. E. Crossley's Observatory, Bermerside, Halifax.

During the past year the 9-inch equatorial has been used for observations of *Jupiter* and measures of binary stars; and the usual observations for time have been made with the transit instrument.

Meteorological observations have been recorded at 9 A.M. and 3 P.M. as in past years, and the usual reports have been sent to Mr. H. Sowerby Wallis, the Registrar-General, and others.

Wolsingham Observatory (Rev. T. E. Espin's).

The $17\frac{1}{4}$ inch has been used during the year for making micrometrical measures of double stars between N. decl. 30° and 60° which have been for the most part neglected. A working list of upwards of 900 stars was prepared early in the year, partly from vol. xl. *R.A.S. Memoirs*, and from the various volumes of the catalogue of the *Astron. Gesellschaft*, and the places for convenience of identification reduced to 1855. Observations were made on 65 nights during the year. The total number of measures made is 2811; 284 stars have been measured on one or more nights. The measures of 83 have been completed, and, together with the measures of 39 new double stars, have been prepared for the press.

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of the spectra of stars and of nebulæ which has been in progress for some years has been continued during the past year.

Experiments in the laboratory in connection with the observatory work are also in progress.

Rousdon Observatory, Lyme Regis, Devon
(Sir Cuthbert E. Peek's).

The building and equipment of the Observatory have been maintained in their usual order. February and March were two very cloudy months, but the rest of the year was generally favourable, and observations were made on 175 nights, which is somewhat above the average. The 6·4-inch Merz equatorial has been kept at the regular observation of long-period variable stars; Argelander's method was followed, as during the previous fourteen years. Five hundred and fifty-nine magnitude determinations have been made. At each observation the light of the variable is estimated relatively to five comparison stars in the same field. Thus, during the year 1900, about 3350 observations of stellar brightness have been made. Twenty-one maxima and thirteen minima have been observed. About twenty-five variables of long period are under regular observation; and these being mostly circumpolar, the light variations are continuously recorded.

Variable Star Notes No. 6 has been published and distributed. This contains observations of *T Cassiopeiæ* for the ten years 1889 to 1898, and of *R Cassiopeiæ* for the twelve years 1887 to 1898. The results are given concisely in tabular form, accompanied by diagrams of the light curves. Other instalments of the work are far advanced and will appear shortly.

Transits of stars have been taken as often as required for the timing of the sidereal clock, which has maintained a very steady rate.

The occultation of *Saturn* was observed under very favourable conditions on September 3. The planet disappeared behind the Moon's dark limb without the slightest distortion; at reappearance the very faint and feeble light of the planet was in strong contrast to the great brilliancy of the Moon's bright limb.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The work of photographing star clusters and nebulæ, which has always been the chief feature of this Observatory, has been steadily pursued during the past year. A list of objects photographed in that period is given below, in the same form as that adopted in previous years.

Preparation was made to photograph the trails of any Leonids that might be caught near the radiant point, if the expected "shower" had occurred. However, though close watch was kept for several nights, at the predicted time, so few meteors were seen that no attempt was made to expose plates.

List of the principal Photographs taken in 1900.

	R.A. h m	Decl. ° ′	Expos. h m
Star magnitudes near γ Pegasi	0 8	+14 38	1 30
H's Nebulous Region No. 1	0 10	+ 9 26	1 30
„ „ „ „ 4	0 25	+ 3 59	1 30
„ „ „ „ 5	0 30	+23 25	1 30
Neb. M. 31 Andromedæ	0 37	+40 43	1 30
H's Nebulous Region No. 8	0 39	+39 16	1 30
„ „ „ „ 9	0 41	+43 30	1 30
„ „ „ „ 10	0 48	+43 35	1 30
Neb. H I 151 Piscium	1 19	+ 9 1	1 0
Neb. M. 33 Trianguli	1 28	+30 9	1 30
Neb. M. 74 Piscium	1 31	+15 16	1 30
Minor planet *Eros*	1 32	+45 13	1 0
Neb. M 76 Persei	1 36	+51 4	1 30
H's Nebulous Region, No. 11	1 41	+29 48	1 30
„ „ „ „ 12	2 28	+19 0	1 30
Neb. M. 77 Ceti	2 37	− 0 26	1 0
Cl. H VI. 25 Persei	3 7	+46 51	1 30
Cl. M. 79 Leporis	5 20	−24 37	1 0
Nebulæ near ζ Orionis	5 37	− 2 10	2 15
Cl. M. 35 Geminorum	6 2	+24 21	1 30
Nebulæ in Monoceros	6 25	+10 0	2 47
Neb. H IV. 3 Monocerotis	6 27	+10 14	1 30
Neb. H IV. 2 Monocerotis	6 33	+ 8 50	1 30
Cl. M. 41 Canis Majoris	6 42	−20 38	1 0
Cl. M. 93 Argûs	7 40	−23 37	1 0
Neb. H I 204 Lyncis	8 36	+50 35	1 30
Neb. H IV. 66 Ursæ Majoris	8 51	+54 11	1 30
Nebulæ M 81, 82 Ursæ Majoris ...	9 47	+69 50	1 30
Neb. H IV. 48 Leonis Minoris ...	9 57	+41 15	1 30
Neb. H IV. 10 Leonis...	10 19	+17 41	1 30
Neb. H IV. 60 Ursæ Majoris	10 32	+54 3	1 30
Nebulæ H I. 116, 117 Leonis Minoris...	10 44	+33 33	1 30
Neb. H I. 225 Ursæ Majoris	11 16	+59 39	1 30
Neb. H I. 20 Leonis	11 19	+11 55	1 30
Neb. H I. 219 Ursæ Majoris	11 19	+39 21	1 30
Neb. H I. 131 Crateris...	11 19	− 9 13	1 30
Neb. H I. 21 Leonis	11 35	+12 4	1 30
Neb. H I. 82 Ursæ Majoris	11 44	+27 35	1 30

	R.A. h m	Decl. ° ′	Expos. h m
Neb. ♅ I. 67 Crateris	11 49	−13 24	1 30
Neb. ♅ IV. 28 Corvi	11 56	−18 17	1 30
Neb. ♅ I. 174 Comæ	11 58	+32 29	1 30
Neb. ♅ I. 175 Comæ	12 10	+33 47	1 30
Neb. M. 99 Virginis	12 14	+14 58	1 0
Neb. ♅ IV. 5 Virginis	12 28	+ 0 39	1 30
Nebulæ ♅ IV. 8, 9 Virginis	12 31	+11 50	1 30
Neb. ♅ IV. 30 Canum Venaticorum ...	12 54	+35 26	1 30
Neb. M. 51 Canum Venaticorum ...	13 25	+47 43	1 0
Neb. M. 101 Ursæ Majoris	13 59	+54 50	2 45
Cl. M. 12 Ophiuchi	16 42	− 1 46	1 30
Cl. M. 10 Ophiuchi	16 52	− 3 56	0 50 1 30
Cl. M. 23 Ophiuchi	17 51	−19 0	1 0
Cl. M. 18 Clypei	18 14	−17 11	0 41
Star mags. near η Serpentis	18 20	− 2 55	1 30
Neb. ♅ IV. 16 Delphini	20 18	+19 47	1 0 (two)
Neb. ♅ IV. 76 Cephei	20 33	+59 48	1 30
Neb. ♅ I. 192 Cephei	20 57	+54 10	1 30
Cl. M. 15 Pegasi	21 25	+11 44	1 0
Cl. M. 30 Capricorni	21 34	−23 39	1 30
Region of *nova* Cygni	21 38	+42 24	2 0
Neb. ♅ I. 55 Pegasi	23 0	+11 47	2 50
♅'s Nebulous Region No. 52	23 0	+29 17	1 30

Daramona Observatory (*Mr. W. E. Wilson's*).

During the early part of the past year experiments were made with different coloured screens, with the idea of photographing the corona at the total solar eclipse on May 28. After some experiments with a screen stained with picric acid, one stained with tartrazine was found to be the most suitable. This was placed in close contact with a Lumière plate which was sensitive to the green part of the spectrum. The 6-inch O.G. was used in conjunction with a fine cœlostat made by Sir H. Grubb, and placed at the disposal of the Director by the Royal Dublin Society. The eclipse was observed at Plasencia in Spain in perfect weather.

In August a Callendar's electric recorder was obtained, for recording the daily amount of solar radiation. A series of experiments were made with different forms of receivers, and the results compared with those of Ångström's pyrheliometer which

measures the amount of radiation in absolute electric units. A new type of receiver has been ordered from the Instrument Company at Cambridge, and will be tried during the present year. Some preliminary experiments were made in the laboratory on the bearing of the laws of radiation on our estimate of the temperature of the Sun. They will shortly be resumed again.

A new breech-piece has been made for the 24-inch reflector by Sir H. Grubb, on the same design as that of the Crossley reflector, and it is hoped that it will give better photographic results than the old one.

The weather during the past year has been the worst on record; in fact, no work was done during the latter half of the year.

Kodaikánal and Madras Observatories.

During 1900 the astronomical work at the Kodaikánal Observatory has been almost entirely preliminary. The buildings are not yet completed, but are now far advanced, and regular observations should be begun early in 1901. Meanwhile regular meteorological and actinometric observations are being made.

At Madras the observations are confined to those necessary for maintaining the regular time service and the meteorological records.

The *New Madras General Catalogue* was distributed early in the year.

Sydney Observatory.

A change in the astronomical staff will make it possible to go on rapidly with the meridian observations required for the photographs of our zone of the heavens. On 1900 March 28 Mr. Sellors retired from his position in the Observatory to accept a position in the computing staff of the Trigonometrical Survey. The vacancy in the Observatory staff was filled on 1900 June 11 by the appointment of Mr. W. E. Raymond, who had for years been assistant to the Chief Surveyor in the Trigonometrical Survey. There Mr. Raymond had a long experience of meridian work in the field, and took up his work of observation and computing at the Observatory without delay. Two junior computers were also added to the staff, and I anticipate a comparatively rapid progress in our meridian work. There has not been any other change in the staff.

Observations.—

1498 zone stars.
704 clock stars.
167 azimuth stars.
858 determinations of collimation and azimuth.

The Sun has been observed regularly for the time ball.

All computations consequent upon these observations are in a very forward condition, the zone stars being nearly complete.

Red Hill Photographic Work.—Mr. Short has obtained satisfactory results in number and quality of work, the results being better and more numerous than those obtained in Sydney.

Plates taken : 175 chart plates.
323 catalogue plates.
102 test plates.

Measurements of Star Plates.—The joint work (Melbourne and Sydney) has been carried on vigorously. A full report of this work will be published later.

We have two of the measuring machines designed by Sir David Gill, and one near completion, which will give the measures direct in minutes and seconds of arc ; it is hoped that it will be rapid and easy to work.

The Library.—During 1900 993 books and pamphlets have been received in exchange. This is 30 per cent. more than in the previous year.

Time Service.—Time balls at Sydney and Newcastle (the latter place 60 miles distant) have been satisfactorily dropped every day.

Lovedale Observatory, Cape Colony (Dr. A. W. Roberts's).

The work of this Observatory has been, as in former years, the observation of variable stars south of decl. $-30°$.

As it was not possible fully to overtake all the work, many short period variables, especially those whose periods have been already rigorously determined, were dropped during the year.

The observations made are as follows :—

	Stars.	Observations.
Algol variables	6	481
Rapid variables	2	295
Short period variables	6	360
Long period variables	70	2476
Suspected variables	6	50
Total	90	3662

The new prismatic equatorial by Cooke arrived at the close of the year.

The instrument has been specially designed and constructed for the observation of variable stars brighter than the tenth magnitude, and also for the projected magnitude survey of the southern heavens.

In front of the object-glass and rigidly bolted to the tube of the telescope is a large prism of clear glass. The telescope tube

rotates in a cradle, and thus the field under observation can be placed in any position. A dial in front of the eyepiece indicates the amount of rotation.

The eyepieces give a large field, the lowest power having a clear diameter of 3°.

The object-glass, which is 2 inches diameter, can be stopped down to any size.

The telescope and its accessories, a dome and transit-room and a sidereal chronometer, is the generous gift of Sir John Usher, of Norton, Midlothian. Lord McLaren personally interested himself in the construction and fittings of the instrument.

Mr. Tebbutt's Observatory, The Peninsula, Windsor, New South Wales.

The observations were from various causes not so numerous as in previous years, and were made chiefly in the winter months. The following is an abstract of the work :—

Meridian Department.—

Nights on which the time was determined		83
Observations of stars with a declination not exceeding 40° ...		423
Observations of stars in high declination for azimuth		107
Separate determinations of	level error	241
	collimation error	24
	azimuth error	75

Extra-Meridian Department.—The following comparisons of planets were made with the filar micrometer on the 8-inch equatorial :—

	Nights of Observation.	Number of Comparisons.	Number of Comparison Stars
(1) Ceres	23	317	9
(3) Juno	8	96	6
(6) Hebe	13	189	4
Jupiter and β^1 Scorpii	5	92	1

There was no comet well placed for observation. A careful but unsuccessful search was made on three nights for Brorsen's Comet, in accordance with an ephemeris forwarded by Dr. Kreutz. A search was also made for Giacobini's Comet, in accordance with the first cable message, which erroneously represented the right ascension as increasing. An amended message was subsequently received, but cloudy weather and strong moonlight combined to prevent further search.

The occultation of *Jupiter* and his satellites was well

observed on September 29. Observations of twenty-seven phases of lunar occultations of stars, and of some of the phenomena of *Jupiter's* satellites, were also made. Twenty-five pairs of the most interesting southern double stars were likewise repeatedly measured with the 8-inch equatorial, and the usual meteorological observations attended to. The whole of the observing and reducing work was executed by the proprietor himself.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1900.

Fifteen new planets were discovered during the past year, as follows :—

Provisional Designation.	Permanent Number.	Date of Discovery, 1900.	Discoverer.	Place of Discovery.
FA	453	Feb. 22	Charlois	Nice
FC	454	March 28	Schwassmann	Heidelberg
FE	...	„ 6	Hirayama	Japan
FF	...	„ 6	„	„
FG	455	May 22	Wolf—Schwassmann	Heidelberg
FH	456	June 4	„	„
FJ	457	Sept. 15	„	„
FK	458	„ 21	„	„
FL	...	„ 26	„	„
FM	459	Oct. 22	„	„
FN	460	„ 22	„	„
FP	461	„ 22	„	„
FQ	462	„ 22	„	„
FS	463	„ 31	„	„
FU	...	Dec. 20	„	„

To these should be added the following planet, discovered in 1899, but not announced till after the last Annual Report :—

FD	452	1899 Dec. 31	Keeler	Lick Obs. (Mt. Hamilton)

The planets provisionally designated FB, FO, FR, FT were found to be identical with (117) *Lomia*, (244) *Sita*, (177) *Irma*, (220) *Stephania*. The identity of FT is, however, not absolutely certain. Planet FQ (462) is identical with the planet DD, discovered in 1896, but not numbered at that time.

The following planets, discovered in 1899, but not numbered at the date of the last report, have since received permanent numbers: ER, 446; ES, 447; ET, 448; EU, 449; EV, 450; EX, 445; EY, 451.

The planets provisionally designated EO, FE, FF, FL do not receive permanent numbers, not having been sufficiently observed.

The following planets have been named: (353) *Ruperto-Carola*, (371) *Bohemia*, (386) *Siegena*, (440) *Theodora*, (444) *Gyptis*, (445) *Edna*.

Of the planets enumerated in the last report as having been observed at one opposition only, the following have since been observed at a second opposition: 220, 328, 382, 388, 425, 432. Special search was also made for 285 and 406, but without success.

The present very favourable opposition of *Eros* is being fully utilised for a new determination of the solar parallax. A conference was held in Paris in July to decide on the best methods of combined work. Upwards of fifty observatories are co-operating, the great majority by photography, though a few astronomers, among whom may be mentioned Professor Barnard with the 40-inch Yerkes equatorial, are making visual micrometric measures. Observatories taking part in the astrographic chart are in most cases devoting their 13-inch equatorials to this work.

During the earlier part of the opposition when the planet was in very high north declination, and southed about midnight, the diurnal method of finding its parallax was the most convenient. Exposures were made as soon as possible after sunset, and again as long as possible after the meridian passage, so as to obtain the maximum displacement. Now that the planet souths early in the evening, and is rapidly moving south, the method of nearly simultaneous observations at two observatories widely separated in latitude will be more suitable.

The Paris Committee has prepared a list of several hundred reference stars of the ninth magnitude or brighter, of which several will appear on each plate and will enable the plate constants to be determined. These stars are being observed on the meridian at several observatories. It is remarked that in practice it may be necessary to compare the planet with fainter stars (say down to the 12th magnitude) lying nearer to it; the photographs will give the means of obtaining the places of these stars with accuracy. An exposure of 6 minutes is found sufficient to record them.

As observations have accumulated, Signor Millosevich has published several successive emendations of the elements of the orbit. The following are his latest elements, based on the observations of the first opposition, combined with a few selected ones at the present opposition; they will of course be liable to further alteration when all the observations now being

made are reduced and discussed, but such alteration will be very small.

Epoch and Osculation.	1898 Aug. 2·5, Berlin M.T.		1900 Oct. 31·5, Berlin M.T.	
M	205° 21′ 43″·0		304° 24′ 44″·7	
π	121 10 55·3	1900·0	121 9 51·8	1900·0
ω	177 39 3·6		177 39 6·2	
Ω	303 31 51·7		303 30 45·6	
i	10 49 35·4		10 49 39·0	
ϕ	12 52 21·2		12 52 47·3	
μ	2015·2730		2015·2372	
log a	0·1637818		0·1637869	

Perturbations by *Venus*, the Earth, *Mars*, *Jupiter* and *Saturn* have been applied (*Ast. Nach.* 3678).

We now know the mean motion with sufficient accuracy to form a forecast of the most favourable oppositions of the coming century. It is clear that an opposition is more favourable in proportion as the interval is smaller between the planet's perihelion passage and the Earth's passage through the longitude of the planet's perihelion. This interval is tabulated for all the years in the century for which it falls below 24 days.

Year.	Interval in Days.	Year.	Interval in Days.
1901	17·42	1945	23·53
1923–24	23·24	1968	17·13
1931	7·65	1975	1·54
1938	7·95	1982	14 05

It will be seen that there is no opposition more favourable than the present for 30 years, and that there are only five more favourable ones in the century.

In the above investigation μ is taken as $2015''\cdot255$, and perturbations, both secular and periodic, have been neglected.

Mr. Henry Norris Russell has made some computations on the perturbations of *Eros* by the Earth and *Mars* (*Ast. Journ.* 483, 484).

The perturbations by the Earth in mean longitude include the term $+747''\sin(7g-4g')$, where g, g' are the mean anomalies of *Eros* and the Earth; the period of this term is 41·24 years, and the whole range in the resulting shift in the place of *Eros* as seen from the Earth is nearly 3°. This will thus in time give a very accurate determination of the solar parallax.

The following are the principal perturbations in mean longitude produced by *Mars*.

Coefficient.	Period in Years.	Coefficient.	Period in Years.
1″·69	27·4	11″·59	40·8
9·42	13·7	22·81	78·0
1·59	9·1	11·85	85·5
2·37	16·2	35 (?)	890 (?)

The last term is very uncertain, and cannot be accurately determined for at least 15 years. But Mr. Russell considers that the other terms may in time give a value of the mass of *Mars* even more reliable than that deduced from the satellites.

A. C. D. C.

The Comets of 1900.

The number of comets discovered in the last year has been small, and the objects themselves have generally been faint and uninteresting. The dearth of interest has been further accentuated by the passage of several periodic comets through perihelion without observation.

On January 31 M. Giacobini discovered a faint comet in the constellation *Eridanus* on its way to perihelion passage. The comet was a faint object, and on February 5 it was described as very faint and difficult to observe in a 16-inch telescope. This small brilliancy remained fairly constant for two or three months, the comet, however, being too near the Sun in April for observation. Owing to its rather large perihelion distance, it remained outside the Earth's orbit, and in July came into opposition, when, owing to its proximity to the Earth, it appeared much brighter than at the date of discovery. Professor Howe, of Denver, recovered the comet on May 27, after its perihelion passage. Assisted by a considerable northern declination, observations were fairly easy onwards throughout July, but the comet grew rapidly fainter in the autumn. The observations are fairly well represented by a parabola, but the definitive orbit is not yet known.

The second comet of the year was independently discovered by M. Borrelly and Mr. Brooks, of Geneva, U.S.A., on July 23, the former astronomer having the priority by about five hours. The object proved to be a fairly bright telescopic comet, having a tail estimated at a degree in length, but it never became visible to the naked eye. Mr. Brooks reports that soon after discovery two faint branches or auxiliary tails were detected, one upon each side of the main tail. Although the principal tail became much fainter as the comet receded from the Sun, it nevertheless maintained its original length of about one degree. The diminution of brilliancy noticed by Mr. Brooks was tolerably rapid, and at the end of September it had scarcely one-thirtieth of the lustre at the time of discovery. No suspicion of ellipticity attaches to this orbit.

The third and last cometary discovery of the year is likely to prove the most interesting. This object was first seen by M. Giacobini on December 20 in 22° S. declination. The comet was moving slightly northwards, and this circumstance may somewhat favour observation, which, it is to be hoped, will be continued as long as possible, since the orbit will beyond doubt prove elliptical. The first approximate elements showed some resemblance to those of 1857 IV., to which Dr. A. Möller assigned an orbit of 234·7 years, founded, however, on but little more than two months' observations. Elliptic elements deduced by Dr. A. Kreutz, without any assumption as to the eccentricity, give the more ordinary period of about $6\frac{3}{4}$ years, and the orbit bears considerable resemblance to those of Wolf and of Barnard (1892 V.). The comet appears to have been in perihelion early in December, and is now rapidly growing fainter. It may be observed till the beginning of March, when, however, it will possess a brilliancy of only one tenth that of discovery; and this, coupled with an unfavourable position in the sky, will render observation very difficult.

Among the comets which have returned to the Sun without being seen is Finlay's Comet of 1886, an object especially interesting from its suspected connection with Lexell's Comet. M. Schulhof has made a most elaborate discussion of the motion of this comet, and, notwithstanding the extreme improbability of its being seen, circulated an accurate ephemeris to assist its discovery, though he recognised the hopeless character of the search. The comet has not been seen owing to its faintness and closeness to the Sun, but at the next return, in 1906, the conditions are very favourable, since the comet approaches the Earth within 0·2 R. On its next journey the least distance between the comet and *Jupiter* will be 0·5 R., and the elements will suffer considerable alteration.

Comet 1894 IV., discovered by Mr. E. Swift, and having a period of 5·855 years, has also passed without detection. This comet is possibly identified with the lost comet of De Vico. Mr. F. H. Seares circulated, but without success, an ephemeris extending from July 23 to December 30, based on a rigorous determination of the orbit. The theoretical brilliancy of the comet showed the hopelessness of the search. In 1894 the comet was seen with great difficulty, and at this return the brilliancy was only one-ninth of what it then possessed. This comet seems to have undergone considerable perturbation, for the date of the perihelion passage, neglecting disturbances, was 1900 August 20, but the complete calculation made the date 1901 February 13.

Another comet which has been sought unsuccessfully is that of Barnard. A most patient search was made by Dr. Schwassmann, of the Königstuhl Observatory, Heidelberg, by means of photography. Some twenty-five photographs were taken on nineteen nights, with an average exposure of two hours, each

plate covering an area of 100 square degrees. The portions of the sky photographed were determined by an ephemeris supplied by M. Coniel. No trace of the comet was found, however, while stars of the thirteenth magnitude impressed themselves on the plate. This comet was not seen on the occasion of its last return in 1894-5, and the error of the date of the perihelion passage, fixed for October 28, may amount to as much as two or three weeks. The chances of its future recovery therefore by means of ephemerides are very remote.

To this list must probably be added Brorsen's Comet, which attained its greatest brilliancy at the beginning of this year.

W. E. P.

Progress of Meteoric Astronomy in 1900.

January Meteors.—Prof. A. S. Herschel, at Slough, watched for the return of the *Quadrantids* on January 2, during the $5\frac{1}{2}$ hours from 11^h to $16\frac{1}{2}^h$. The number of meteors seen was 130, of which the paths of 80 were registered. About 29 of the latter belonged to the special shower of the epoch, while the remainder were furnished by radiants in *Boötes*, *Draco*, *Hercules* and *Ursa Minor*. Mr. W. E. Besley, at Clapham Common, S.W., also obtained an observation on January 2, between $11^h\ 38^m$ and 13^h, and counted 30 meteors nearly half of which were *Quadrantids*. At $11^h\ 59^m$ he recorded a 1st mag. meteor which was also noted by Prof. Herschel, at Slough. An observer at Chalfont, Buckinghamshire, reports that on January 3, 6^h to $6^h\ 30^m$ A.M., he noticed "several fine shooting stars which had tails and burst like rockets." Mr. R. Service, at Dumfries, states that on January 4, between 6 A.M. and daylight, he counted more than 30 very fine meteors, hardly one being under 1st mag. The prevailing colour was yellow.

April Meteors.—Prof. Herschel found meteors very rare on the evenings immediately preceding the *Lyrid* display, only 7 being recorded during 7 hours' watching on April 15, 16, 17, and 18. On later nights there was a marked increase; on April 19 he noted 12 meteors in $4\frac{1}{2}$ hours, on April 20, 25 meteors in 5 hours, and on April 21, 35 meteors in $4\frac{1}{2}$ hours. There were about 15 *Lyrids* with pretty rich outlying radiants in *Draco* ($261° + 48°$), and *Lyra* ($280° + 47°$). Observations were also made by Mr. A. R. Hinks, Cambridge, A. King, Leicester, and others, but meteors generally were scarce and the *Lyrid* shower offered very feeble evidence of its presence.

May Meteors.—Several observers in England awaited the return of the *Aquarids* on the morning of May 4, and a few of these bright, long-pathed meteors were observed. But the position of the radiant is unfavourable to the shower's observation in high northern latitudes. That it returned pretty actively is certain, for the Rev. J. T. Bird noticed it in South Africa. While bivouacking on the veldt, on the morning of May 3, he observed

a small shower of swift meteors with streaks radiating from somewhere between *Altair* and *Fomalhaut* (*Journal of the B.A.A.*, vol. xi. p. 32). A conspicuous meteor of this shower with a very long path and streak was seen by Prof. Herschel, at Slough, and by Mr. J. H. Bridger, at Farnborough. The real path works out satisfactorily from the pair of observations and it is included in Table II. This is the first *Aquarid* of the May epoch of which the heights &c. have been deduced. The computed velocity of 28 miles per second is much slower than the theoretical speed of 41 miles per second.

July and August Meteors.—There was a full moon near the period of the maximum of the *Perseids*, and the principal observations were effected this year during the last half of July. Meteors were tolerably numerous, and the *Perseids* were in evidence on and after July 19. The richest of the minor showers was formed, as usual, by the δ *Aquarids*. Several early *Perseids* were recorded at two stations and the positions of their radiants show the motion of the *Perseid* centre very distinctly. In presence of moonlight on August 10 there were few meteors, but on August 12, when the atmosphere was very clear, a fair number of *Perseids*, including some brilliant specimens, were observed. Several large fireballs appeared in July and August and were well seen ; their real paths are given in Table II.

October Meteors.—The *Orionids* were fairly active on October 23, but the strongest shower of that date appeared to be from near ξ *Geminorum* with radiant at 99°+13°. The latter is a well-known companion radiant to the *Orionids*, and it seems to have been unusually active in 1900, yielding very swift streak-leaving meteors. The true *Orionids* appeared to be less numerous than usual, but not many observations were obtained between October 18 and 22. October 21 was a beautifully clear frosty night, and several very fine meteors were recorded at various places. The most brilliant of these were not *Orionids*, as they travelled slowly from radiants in the S. and S.W. quarters of the sky.

November Meteors.—The non-arrival of the *Leonids* formed a marked and disappointing feature of the observations made at the middle of November. They were sedulously looked for at all the chief observatories, and large numbers of amateur astronomers and private persons made efforts to witness the display should it appear. But the same story of meagre results comes from all parts of the globe. There were a few *Leonids*, it is true, with their characteristic streaks and rapid flights, but a brilliant exhibition such as that of 1866 was entirely wanting. In fact the shower, such as it was, scarcely excelled several of the contemporary streams of the epoch. The true explanation doubtless lies in the fact stated by Dr. Downing, that the dense body of meteors has been perturbed by the major planets in sufficient degree to enable it to escape *rencontre* with the Earth. However much we may deplore the conditions which produced this result, we shall hope for a revival of the shower and will continue to watch

for any stray *Leonids* that may appear on or about November 15 in the few ensuing years. In 1900 they were most numerous on the morning of November 15, when 2 or 3 per hour were counted by single observers. But this rate is far below that observed in 1879 and 1888 when the parent comet was not very far distant from perihelion. From the reports of various observers it is certain that during the last few years the *Leonid* shower, instead of showing increasing numbers, has perceptibly declined until it has become scarcely noticeable. In 1900 one of the chief mid-November showers was the *Taurids*, which supplied some very brilliant slow-moving meteors.

The *Andromedids* were looked for by Prof. Herschel, Mr. A. King, and others during the last week of November, but very few of the meteors were seen. As the shower recurred actively in 1899, a bright display was not expected.

December Meteors.—Mr. T. H. Astbury, at Wallingford, Berks, observing on December 13, $8^h\ 10^m$ to 9^h, saw 15 *Geminids* and a few other meteors. At a later hour the shower had become less active. On other nights of the epoch the sky was overcast at Wallingford. Mr. C. L. Brook, at Meltham, near Huddersfield, saw a fair number of *Geminids* both on December 11 and 12. Prof. Herschel, at Slough, watched on December 13 between $11\frac{3}{4}^h$ and $13\frac{1}{4}^h$ and saw about 20 meteors, including about 6 *Geminids*. The various reports show that the shower returned in fair strength and that it was observed to the best advantage on the very clear night of December 13.

The following is a list of real paths of bright meteors observed in England during the past year :—

Date. 1900.		G.M.T. h m	Brightness.	Height at First. miles.	Height at End. miles	Length of Path. miles	Velocity per Sec. miles	Radiant Point. ° °	Observers.
Jan.	2	11 58½	>1	57	40	44	22	228+53	2
	9	2 55	☽	59	23	174	...	280−12	10
May	3	13 58	2	54	49	155	28	337± 0	2
	5	8 20	F	64	43	112	20	245+ 5	15
June	10	9 10	F	65	28	55	32	336+73	9
July	15	10 13	2×♀	51	21	78	16	297−11	3
	17	8 47	F	58	15	175	slow	249−20	17
	18	11 33½	♃	52	50	45	11	214−10	3
	19	11 49	>1−♃	81	54	43	35	17+50	2
	24	10 49	3×♀	68	27	103	19	280−15	5
	30	10 45	F	95	50	92	swift	30+52	5
Aug.	19	10 36	3×♀	56	29	62	slow	346± 1	3
Sept.	2	6 54	F	85	20	84	slow	334+57	37
	16	8 44	2×♀	50	32	86	slow	324−25	4
Oct.	21	8 35¼	=☽	68	20	66	11	300+22	300
	,,	11 58	♀	63	48	37	25	350− 4	2
	27	11 42	3×♀	76	67	34	42	136+34	2
Nov.	27	11 10	>♀	57	17	40	...	47+45	3
Dec.	13	10 18½	>1	59	44	24	...	109+24	2

Principal Meteoric Showers observed in 1900.

Date.	Radiant.	No. of Meteors.	Observer.	
Jan. 2	229°+52°	29	A. S. H.	*Quadrantids*
„	230+54	13	W. E. B.	„
April 16–21	218−31	13	A. S. H. & others.	
„	255+27	12	„	
„	255+37			
„	233+63	11	„	
„	275+35	23	„	*Lyrids*
July 18–30	316+48	9	W. F. D.	
24–30	338−10	24	„	*Aquarids*
30	31+54	10	„	*Perseids*
July–Aug.	335+72	12	„	
Aug. 18–26	346+ 1	12	„	
Aug. 22–26	333+28	11	„	
Aug. 24–Sept. 2	47+43	14	„	
Sept. 29-30				
Oct. 23–27				
Aug.–Sept.	72+65	11	„	
Aug. 12	48+58	12	A. K.	*Perseids*
Sept. 1–20	334+57	12	W. F. D.	
Oct. 23–27	99+13	13	„	
Oct.–Nov.	57+ 9	11	A. S. H.	
„	57+18	11	„	
„	44+12	10	„	
Oct. 23–27	43+12	8	W. F. D.	
Nov. 14–15	150+22		W. E. B.	*Leonids*
Nov. 15	151+23	6	T. H. A.	„

A. S. H., Prof. A. S. Herschel; W. E. B., W. E. Besley; A. K., A. King; W. F. D., W. F. Denning; T. H. A., T. H. Astbury.

Stationary Radiation of Meteors.—This interesting feature has recently been investigated and discussed by Professors H. H. Turner and A. S. Herschel, Dr. Bredikhine, M. O. Callandreau, and others. Professor Turner has suggested (*Monthly Notices*, 1899 January and 1900 April) that meteors in passing near the Earth are perturbed in such a manner that after a very long interval of time its cumulative effect on an originally compact group is to distribute it along a considerable section of, if not completely round, the Earth's orbit. The character of the disturbance is such that the apparent radiant of the meteors remains unaltered, while the duration of the shower is much protracted. Professor

Herschel, while admitting the ingenious and simple nature of Professor Turner's theory, has offered another possible explanation. He assumes the existence of a ring of small planetary bodies round the Earth, into which meteors ejected from stars (distant suns), and having enormous velocities (in accordance with the late Mr. R. A. Proctor's views), were dashed. These violent incursions must expel many of the constituents of the ring, and it is this *débris* which in later times is supposed to have supplied stationary radiants. The fragments forming the *débris* would set off in new orbits round the Sun, and returning to the Earth must present one and the same relative radiants imparted to them by the volleying from celestial spaces. Dr. Bredikhine, in the *Bulletin de l'Académie Impériale des Sciences de St-Pétersbourg*, has combated Professor Turner's view, and feels disposed to explain stationary radiation on the idea that it is an apparent effect due to the sequence and commingling of different streams exhibiting many varieties of orbit. Meteoric systems are so numerous that several showers must often succeed each other from similar if not identical directions, though the orbital elements present little resemblance. But M. Bredikhine in a further communication practically admits that stationary radiants within moderate limits (five or six weeks) of duration may be the outcome of perturbation by the larger planets upon the meteoric particles. M. O. Callandreau has also approached this subject, and concludes that if the condition (derived from the criterion of Tisserand, in *Comptes Rendus* for 1891) is fulfilled, there may ensue repetitions of active showers presenting all the appearance of stationary radiants. But in the case of radiants enduring for several months, it must be possible to comprehend in the same family of meteors motions direct and retrograde, and with perihelion distances differing greatly from each other.

Supposed Ancient Showers of Andromedids.—Professor D. Eginitis, Director of the Observatory at Athens, alludes in his report for 1899 to some ancient meteoric showers. A display lasting all night was described by the patriarch Nicephorus, and its historical connections indicate the year as 752. This may have been an ancient storm of *Andromedids*, as three returns of Biela's Comet are equal to twenty years, and the meteors were seen in 1852, 1872, and 1892. Theophanes records that in the year of the famous revolt of Nika (532) a great fall of stars came from the evening till the dawn. M. Eginitis considers this another return of the *Andromedids*, as it corresponds with the 20-year period. There was a meteoric shower in the autumn of 558, and a large comet in 518. These may possibly comform with the *Andromedid* displays of 1798 and 1838. The *Lyrids* of April are probably represented by a shower recorded in 763 by Theophanes, and in 1122 by Domno Alberico.

*Velocity of Meteors determined by Photography.**—The instru-

* From a paper by Dr. W. L. Elkin read before the Astronomical and Astrophysical Society of America at its second meeting, 1900.

ments in use at the Yale Observatory, U.S.A., for the photographic observation of meteors have been supplied with an arrangement for the determination of their velocity. The idea seems to have been first suggested by J. Homer Lane in 1860. An attempt was made in 1885, on the occasion of the *Andromedids* by Zenker at Berlin, and the suggestion was lately revived by Professor Fitzgerald. The Yale apparatus consists of a bicycle-wheel rotating in front of the cameras, and carrying a number of opaque screens. There are at present twelve of these screens, and the rotation is effected at the rate of thirty to fifty turns a minute, by means of a small motor worked by three or four bichromate cells. It will be advisable to increase the number of occultations. At each revolution a record is made at the chronograph, so that the wheel's velocity at any instant is always known. The length of the interruption of a meteor trail and the resulting velocity are easily derived from the plates if the meteor is also recorded on a plate at a second station at Hamden, distant about 3280 yards. With the exception of one of the *Andromedids* much smaller velocities than those derived on the assumption of a cometary velocity were found. The observed velocities lead to orbits of a very improbable character, having periods from 1·25 to 1·80 year, so that it would seem an almost certain conclusion that the atmospheric retardation has amounted to from five to nine miles. The following are the radiants and velocities determined from the observations :—

Date. 1899.	G.M.T.	Apparent Radiant. α δ	Observed Heights.		Observed Velocity.	Computed Velocity.	Meteor.
	h m s	° °	Miles.	Miles.	Miles.	Miles.	
July 31	17 4 30	28·55 + 57·31	55	47	31·3	36·2	Perseid
Aug. 7	14 25 25	288·12 − 6·20	31	28	7·6	16·9	
Aug. 8	16 32 47	43·55 + 56·33	63	59	31·3	37·5	Perseid
Nov. 24	16 31 25	27·43 + 40·33	58	56	12·5	12·2	Andromedid
Dec. 12	21 43 0	113·44 + 33·36	56	54	22·7	30·8	Geminid

Solar Activity in 1900.

The diminution of solar activity has steadily continued during the past year, and if the minimum has not been already reached, it is very near. The Stonyhurst drawings, supplemented by eye-observations made by Mr. Hadden of Alta, Iowa, U.S.A., and Professor Moye of Montpellier, show that the sun was spotless on 156 of the 312 days of observation, or on 50 per cent. The percentage numbers of spotless days from the Greenwich records for the two years preceding were 13·2 and 33·7 respectively. The yearly mean of the visible disc-area of the spots from the Stonyhurst drawings is 0·55, a diminution of 28·6 per cent. as compared with the mean 0·77 for the year 1899. The greatest visible actual area shown on the Greenwich photographs on any single day by any individual group was

attained on June 30 by the group which reached the western limb on July 1. This was due to a sudden enlargement of a group which had been quite small during the major part of its period of visibility. The greatest average area for any group was attained by the moderately large group which crossed the disc during October 17–28, and re-appeared again November 13–23. Since that date, until the end of 1901 January, the Sun has been spotless, with the exception of three or four days on which minute dots were seen on the surface. There has also been a remarkable absence of bright faculæ during several considerable periods, and the observations of M. Guillaume made at Lyon show a diminution in the mean area of the faculæ for the first nine months of 1900 of 34 per cent. as compared with the same period of the previous year. The same observer reports the appearance of a small spot in a very high latitude—48° N.—on September 15, but it must have been very faint or very short-lived, as the Greenwich photographs do not confirm it. But on September 2 and 3 a group consisting of two small spots in dense bright faculæ, and nearing the preceding limb, was drawn at Stonyhurst as in longitude 105° and south longitude 25°, and was also observed at Lyon and Greenwich. The same group is probably identical with that observed on August 29 and 30 by Mr. Hadden in high south latitude, although the Sun's disc was absolutely clear on August 31. This group is in all likelihood the harbinger of the new cycle, and its appearance, taken with the fact of the present absolute quiet of the Sun's surface, would point to the presence of the minimum. The chief periods of solar-spot quiet during the year have been January 2–10, February 16–March 1, March 12–24, May 8–13, June 4–13, July 5–15, July 26–August 6, August 17–29, September 13–October 6, October 29–November 11, November 27–1901 January 31. Not only have the spot-groups seen during the past year been small in area, but, with the exception of three or four groups which appeared a second time, they have been very evanescent in character. In type they have been mostly groups of small spots, and there was no example of the formation of a round regular spot with a dark umbra. Even in such groups as appeared of the two-spot type the umbræ of the principal spots were soon disrupted by the formation of bridges.

A. L. C. and E. W. M.

Solar Prominences in 1900.

A very slight reduction in the mean numbers observed is shown for the past year, although the average size of the prominences has actually increased a little.

Compared with 1899 the mean daily numbers are :—

	1899.	1900.
North hemisphere	3·27	3·17
South „	3·73	3·61
Total	7·00	6·78

The distribution in latitude appears to have followed very closely that observed for several years past, and the limit in high latitudes, beyond which prominences are practically absent, has been as well marked as in every year since 1894, when the high latitude zones of activity closed in over both poles simultaneously and large prominences were frequent in the polar regions.

The position of the limit in both hemispheres and for the last three years has been approximately :—

	North Hemisphere.	South Hemisphere.
1898	+56°	−53°
1899	+54	−53
1900	+60	−55

It is of interest to note that this limit of prominence formation towards the poles appears to correspond with the north and south edges of the great coronal streamers, as observed in recent eclipses. The mean position of the edges of the east and west streamers in 1898 and 1900 are a few degrees nearer the poles than the prominence limits ; but conforming to the latter, as indicated in the above table, the streamers approach nearer to the pole in the northern hemisphere than in the southern.

Metallic prominences have been very infrequent during 1900, three only being observed. These were recorded as follows :—

Date.	Solar Latitude.	
1900 September 21	− 2°	W. limb.
„ October 2	−18° to 25°	W. „
„ „ 16	−15°	E. „

No large prominences of the eruptive class have been observed. J. E.

Total Solar Eclipses.

1900 *May* 28.

The track of this eclipse, which lay over the United States, through Portugal and Spain to Algiers, offered a number of accessible points of observation for both American and European astronomers, and, as the weather conditions throughout the whole length of the line were entirely favourable, a large number of observations and photographs were secured.

The British official parties were distributed as follows :—

(1) At Ovar, on the coast of Portugal, Mr. Christie took photographs of the corona with the Thompson photo-heliograph, similar to those taken in India in 1898, while Mr. Davidson under his direction secured photographs on a small scale showing

the extension of the corona ; and Mr. Dyson secured a series of slit spectroscope photographs showing the spectrum of the Sun's limb and of the corona.

(2) At Santa Pola, in Spain, Sir J. N. Lockyer and party, assisted by the officers and men of H.M.S. "Theseus," carried out an extensive series of observations, similar in scope to those which the same observers carried out at Viziadrug in 1898. The prismatic camera work was extended by using a lens of longer focus and consequently obtaining a greater linear extension in the resulting photographs. The series obtained gives a complete record of the spectrum of the chromosphere at various depths, and is apparently quite similar in character to that obtained before.

At this same station Dr. Copeland took photographs with the 40-foot telescope of 4-inch aperture, and with a small Iceland spar and quartz prismatic camera.

(3) At Algiers Professor Turner used the photo-heliograph objective with the Dallmeyer secondary magnifier to obtain corona photographs on a scale of $1\frac{3}{8}$ inch to the Sun's diameter. The two "Abney" lenses were not used separately on this occasion, as it had been thought preferable to recombine them into a doublet. The series of photographs of the corona, dating from 1882, secured by these lenses has therefore been broken. It was considered that there was no advantage to be gained by its continuance, as the photographs resulting from the use of the two lenses with secondary magnifiers are in every way superior. Professor Turner also took photographs with a polariscopic camera, the results of which are interesting, and show plainly the polarisation of the corona, though their full meaning cannot be discussed until the quantitative measurements are made. Mr. Newall, who was also at Algiers, planned and successfully executed an important series of observations, embracing slit spectroscope photographs of the Sun's limb and corona with a four-prism spectroscope, spectroscopic photographs of the corona with a large objective grating, and photographs with a polariscopic camera, consisting of Savart plates in front of a Nicol's prism. The resulting photographs with the latter instrument show strong Savart bands over the corona, and as a very complete series of observations on the general polarisation of the sky were made at the same time, the full discussion of these observations is likely to lead to important conclusions.

(4) At Mazapan, in Algeria, Mr. Evershed used three prismatic cameras, one of 2-inch aperture with two crown glass prisms, one of 9-inch aperture with two flint prisms, and one of about 1-inch aperture with two double quartz prisms. The station was specially selected in order that it might be as near as possible to the edge of the band of totality and photographs of the chromosphere spectrum thus obtained in high solar latitudes. Though, owing to an error in the *Nautical Almanac* value for the lunar diameter, the actual station was found to be

just outside the limit of totality, the series of photographs are nevertheless of high interest, and establish the fact that the spectrum of the Sun's limb is the same in polar regions as in low latitudes. From these photographs, as well as from those obtained by other observers, it seems certain that the spectrum of the Sun's limb is as constant in character as the dark line spectrum.

Mr. Wesley, who by the courtesy of M. Trépied, Director of the Algiers Observatory, had placed at his disposal the equatorial coudé of 0·3-metre aperture, observed the corona directly, principally with the view of determining whether it showed finer structure than is visible in the photographs, an observation for which his large experience and study of corona photographs rendered him peculiarly competent. His conclusions were definite and negative, *i.e.* that all the detail which can be distinguished by the eye in a telescope is visible on good photographs taken on a sufficiently large scale.

In addition to the official observers parties from Dublin and Edinburgh and a large number of members of the British Astronomical Association proceeded to stations on the line of totality and made successful observations. Among these may be mentioned Dr. Rambaut, Mr. W. E. Wilson, Dr. Downing, Mr. and Mrs. Maunder, Mr. Crommelin, Mr. Franklin-Adams, and the Rev. J. M. Bacon.

Some French and German astronomers also observed, but no complete reports of their results are yet to hand. The American astronomers made very complete arrangements for observations in that portion of the shadow track that crossed their continent. Space does not permit of more than a brief mention of the more important work.

The U.S. Naval Observatory equipped two stations where, in addition to the usual corona photography, an extensive series of prismatic cameras and objective gratings were employed in the skilful hands of Doctors Ames, Crew, and Humphreys, Mr. Jewell, and Dr. Huff.

From the Smithsonian Observatory an expedition, under the direction of Professor Langley, undertook a programme of work, the most important items of which were photographs of the corona with a telescope of 12-inch aperture and 135 foot focus, used with a cœlostat, and bolometer observations of the inner corona.

The series of photographs obtained with the large instrument are particularly fine, and show a great wealth of detail in the inner corona.

The bolometer results appear to Professor Langley to show that the corona neither reflects much light from the Sun nor emits much heat of its own, and therefore seems rather to be giving light in a manner not associated with a high temperature.

The Yerkes Observatory party successfully employed a number of prismatic cameras, the results of which have been discussed by Professor Frost, who arrives at the conclusion that

the existence of a reversing layer at the base of the chromosphere is fully confirmed. Professor Barnard used a telescope of 61·5 foot focus and 6-inch aperture for photographing the corona, and obtained views showing the inner corona and prominences with great perfection.

Professor Hale attempted a determination of the heat radiation with the bolometer, but, owing to an unfortunate accident, no results were secured.

The Harvard Observatory party, under the leadership of Mr. W. H. Pickering, in addition to an extensive programme of photographic and spectroscopic work, undertook an elaborate search for an intra-Mercurial planet with a battery of nineteen cameras, which, however, proved abortive.

In addition to the above there were also parties from Princeton Observatory, Brown University, Georgetown College, and some others, but no details are yet to hand showing that results of any special importance were secured.

Professor D. P. Todd was stationed at Tripoli, at the eastern end of the line of totality, and used for the first time his automatic battery of instruments.

Mr. Burckhalter successfully employed his rotating sector apparatus for graduating the exposures in the corona photographs, and obtained some views of great beauty.

To summarise the results we may say that this eclipse is not remarkable for any striking advance. The spectroscopic records are not essentially different from, nor are they superior to, those obtained in India in 1898, and, while the detailed examination of the plates may bring new facts to light, it would at present appear that they practically only confirm the Indian results.

The polariscopic work is of undoubted importance, and when fully examined may throw light on the question of the physical condition of the corona.

The bolometric results are interesting, and if further observations of this character should confirm the idea of the absence of heat or infra-red rays the case for the electrical origin of the coronal light will be a strong one.

The corona was of the same type as those of 1878 and 1889.

1901 *May* 18.

The long duration of totality makes this eclipse an important one, and it is to be regretted that the great distance of the shadow track from England renders it impossible for many observers to spare the time for the necessary journey. As far as is known at present, Mr. Maunder will proceed to Mauritius, and Messrs. Dyson and Newall to Sumatra. The latter will again attempt the spectroscopic determination of the rotation of the corona, which failed in India owing to insufficient exposure of the plate.

As on this occasion an exposure of about three times the former amount can be given, it is to be hoped that a successful result will be obtained.

E. H. H.

Double Stars.

The following summary of references is arranged under two heads, "Observation" and "Calculation," as in former reports, and abbreviated titles have been used as follows :—

M. N.: Monthly Notices R.A.S.
A. N.: Astronomische Nachrichten.
A. J.: Astronomical Journal.
Ast. Soc. Pac. : Astronomical Society of the Pacific.

Observation.—Attention may first be called to measures of a few special stars :—

70 *Ophiuchi*		Schur, *A. N.* 3621, Bd. 151, Göttingen heliometer, 1899.
β 883	...	E. E. Barnard, *A. J.* 477, vol. xx. p. 170, measures in 1898 and 1899.
		R. G. Aitken, *A. N.* 3638–9, Bd. 152, in 1899.
		T. Lewis, *M. N.* 1900 April, vol. lx. p. 492, in 1899.
Sirius	...	E. E. Barnard, *A. J.* 477, vol. xx. p. 167, in 1899·8.
		T. J. See, *A. N.* 3654, Bd. 153, in 1900·3.
		R. G. Aitken, *A. N.* 3638, Bd. 152, in 1899.
Procyon	...	E. E. Barnard, *A. J.* 482, vol. xxi. p. 16, in 1898–9–1900.
		T. J. See, *A. N.* 3654, Bd. 153, in 1900·3.
		R. G. Aitken, *A. N.* 3638–9, Bd. 152.
		T. Lewis, *M. N.* 1900 April, vol. lx.

The following papers deal with observations of Double Stars :—

New Double Stars—

Royal Observatory, Greenwich. M. N. 1900 June, vol. lx. p. 595. "*Capella* as a double star."

Hussey and Aitken. Ast. Soc. Pac. No. 75, vol. xii. pp. 201, 202. "*Capella* as a visual double."

E. E. Barnard. A. N. 3621, Bd. 151, New Triple B. D. + 34°·732.

W. J. Hussey. A. J. 480, vol. xx. 100 new doubles in zone −10° to −13° Dec., 40 pairs under 1″.

W. J. Hussey. A. J. 485, vol. xxi., 100 new doubles, 25 under 0″·5.

R. G. Aitken. A. N. 3635, Bd. 152, 47 new pairs in zone −2° to −10° Dec. ; 16 under 1″.

R. G. Aitken. Ast. Soc. Pac. No. 74, vol. xii. p. 127, 5 new pairs.

R. G. Aitken. *A. N.* 3668, Bd. 153, 62 new pairs, 12 under 0″·5.

C. D. Perrine. *Ast. Soc. Pac.* No. 74, vol. xii. p. 129, 2 new pairs.

In the course of the year 1900 the following papers have also appeared :—

Doberck. *A. N.* 3680–1. Measures of double stars made with the 14-inch refractor at Copenhagen in the year 1900.

Glasenapp. "Mesures micrométriques d'étoiles doubles faites à Domkino et à St-Pétersbourg, 1899." Northern pairs 70 under 5″·0, 128 over 5″·0.

Knorre, A. N. 3632, Bd. 152. "Beobachtungen von Doppelsternen, Berlin." Double-image micrometer on 9·6 inch refractor, 26 Σ pairs about 3″.

Boothroyd and Cogshall. *A. J.* 478, vol. xx. p. 173. Double-star measures made with the Lowell 24-inch refractor in 1898. All of these relate to Burnham stars, 145 pairs.

Cogshall. *A. J.* 486, vol. xxi. p. 41. Observation of Dr. See's stars between 18^h and 24^h. A fine set of measures. He finds changes in λ 348, 370, 388, 389, 435, 441, 469, 474.

Aitken. *A. N.* 3638–9, Bd. 152. Measures of 204 pairs, made with the 36-inch refractor of the Lick Observatory. Many are difficult Burnham stars.

Stimson Brown. *A. N.* 3645–6, Bd. 152. Measures of 250 pairs made in 1897–8–9 with 26-inch Washington refractor ; 37 under 0″·5.

J. Comas Solá. *A. N.* 3679, Bd. 154. Measures of 60 selected pairs made with 6-inch refractor by Grubb. 4th series.

Royal Observatory, Greenwich. *M. N.*, 1900 April, vol. lx. 494. "Results of Micrometric measures of double stars made with the 28-inch refractor in the year 1899."

Royal Observatory, Greenwich. *M. N.* 1900 April, vol. lx., p. 516. Measures of double stars from photographs taken with the 26-inch Thompson refractor.

E. E. Barnard. *A. J.* 488, vol. xxi. p. 64. "Measures of *Krueger* 60 and β 1291." Note pointing out motion in β 1291.

R. G. Aitken. *Ast. Soc. Pac.* No. 76. Measures of κ *Pegasi* in 1900.

Calculation.—The following papers dealing with calculation and general literature have appeared in the course of the year :—

95 *Ceti* ... T. J. See, *A. N.* 3629, Bd. 152 ; orbit, period 150 years.

τ *Cygni* ... T. J. See, *A. N.* 3629, Bd. 152 ; orbit, period 57·25 years.

τ *Cygni* ... R. G. Aitken, *Ast. Soc. Pac.* No. 74, vol. xii. p. 103 ; orbit, period 45·1 years.

β 883 ... T. Lewis, *M. N.* 1900 Apr., vol. lx. p. 492 ; orbit, period 15·8 years.

Σ 367 ... Dr. Glasenapp, *A. N.* 3669, Bd. 153 ; orbit, period 224 years.

ζ *Herculis* T. Lewis, *M. N.* 1900 December, vol. lxi. p. 74 ; orbit, period 32 to 35 years.

ΟΣ 341 ... W. Hussey, *Ast. Soc. Pac.* No. 72, vol. xii. p. 38 ; note on, as a rapid binary.

ΟΣ 165 ... W. Hussey, *Ast. Soc. Pac.* No. 75 ; motion due to proper motion.

β 107 ... Dr. Kreutz, *A. N.* 3652, Bd. 153 ; identification of, note on motion.

Capella ... W. H. M. Christie, *M. N.* 1900 December, vol. lxi. p. 70 ; orbit, 104 days.

δ *Equulei* W. Hussey, *Ast. Soc. Pac.* No. 76, orbit, period 5·8 years.

99 *Herculis* R. G. Aitken, *Ast. Soc. Pac.* No. 76, orbit, period 63 years.

W. Hussey. Ast. Soc. Pac. No. 74. "Notes on the progress of double-star astronomy."

H. C. Plummer. "An application of projective geometry to binary star orbits." *M. N.* 1900 April, vol. lx. p. 485.

Beyond those works already tabulated, Professor Burnham's *General Catalogue* calls for special notice.

The general catalogue of stars discovered by Professor Burnham forms vol. i. of the Yerkes publications. It is modelled on the same lines as those adopted in the publications of the Lick Observatory. The stars are arranged in order of Right Ascension, with all the measures of each pair in chronological order ; notes are added where necessary, also diagrams and orbits and complete references to the original sources. Hence those stars needing observation can be at once noted. In all there are 1290 pairs, of which 723 have separations less than 2″, and about 200 may already be classed as binary, while five have completed at least one revolution under Professor Burnham's own observation, viz. :—

β 989,	κ Pegasi,	period	11·4 years
β 883		,,	15·8 ,,
β 101,	9 Argûs,	,,	23·3 ,,
β 733,	85 Pegasi,	,,	25·7 ,,
β 151,	β Delphini,	,,	26·7 ,,

Both by his discoveries and researches Professor Burnham has established for himself a remarkable position as leader in this branch of astronomy. The introduction to the volume is of great value ; and even astronomers not directly interested in double star work will find in it ample material for study. His experience of telescopes must be unique. A list of those used by him is here appended, with the number of double stars discovered with each.

6-inch	Private Observatory	451
18½ „	Dearborn „	413
36 „	Lick „	198
15½ „	Washburn „	87
12 „	Lick „	56
9·4 „	Dartmouth „	24
26 „	Naval Observatory, Washington	14
40 „	Yerkes Observatory	8
16 „	Warner Observatory	2
		1253

T. L.

Variable Stars.

The subject of variable stars is coming into increased prominence, as in it are included problems of orbital and physical (or chemical) change, which are dealt with also by the spectroscope; and the correspondence of visual or photometric observations of light changes with spectral changes adds an enormous reality, so to say, to numberless phenomena in the stellar universe. Up to the past few years variable stars were looked upon as more or less outside the pale of ordinary observatory routine, but there is now great activity in this department of astronomy, especially in America, where the discovery of many variable stars in star-clusters by Professor S. I. Bailey is perhaps one of the most notable advances in late years, opening up deep questions in cosmical physics.

Out of 19,050 stars examined by Professor Bailey in certain star-clusters, 509 are found to be variable. Thus there are in the cluster *Messier* 3 132 variables, in ω *Centauri* 125, in *Messier* 5 85, *Messier* 15 51, and so on in diminishing numbers in other clusters. Of the 106 variables in ω *Centauri* whose periods have been determined, 98 have periods less than twenty-four hours. The longest period is 475 days, the shortest $6^h\ 11^m$. The largest range in variation is about five magnitudes. Professor Pickering points to the remarkable regularity in the period of these stars as worthy of attention. Up to the present variables have not been discovered in any except dense globular clusters, of which *Messier* 3, *Messier* 5, and the great cluster in *Hercules* may be taken as examples.

In *Messier* 5 all the variables have nearly the same period, about half-a-day, and nearly same range of magnitude, 14^m to 15^m. Dr. Johnstone Stoney considers these stars were probably nearly alike in physical condition, brightness, star-spot period, and period of internal dynamical vibration. If so, the resemblance would continue during their subsequent history, and he suggests in consequence of shrinkage the star-spot period and the

period of internal dynamical vibration have become nearly equal.

Professor Pickering continues the work of observation of variables for which the Harvard College Observatory is so famous, and we learn that 24,000 photometric comparisons have been made for the year ending September 30 last. Amongst a vast quantity of other work, the observations of 17 circumpolar variables of long period made by Argelander's method from 1890 to 1899 are in print and will shortly be distributed; 30,000 observations of 128 variables in ω *Centauri* are nearly ready for the printer; and a bibliography of variable stars is in hand, containing 15,000 entries.

With the meridian photometer of this Observatory, the observations of stars south of dec. $-30°$ of $7^{m}\cdot0$, and brighter, were completed early in December at Arequipa, and the total number of settings, including those made with the first meridian photometer, reaches the enormous total of 999,864—*i.e.* nearly a million observations.

During the examination of photographic plates at the Harvard Observatory, a new star was discovered in the constellation *Aquila* by Mrs. Fleming, making the 6th Nova found in this investigation. Fifty-six new variable stars discovered on plates have not yet been measured and announced.

Turning nearer home, variables have been discovered by Dr. T. D. Anderson, as follows :—

	R.A. h m s	Dec. ° ′ ″		
1	0 8·5	+46 12	(1855).	
2	5 44·1	+15 45	„	
3	17 55 24·7	+19 29 20	(1900).	A comparatively rapid long period var.
4	17 55·6	+54 51	(1855).	
5	19 33 48·2	+ 9 35·4	(1855).	B.D. +9° 4205.
6	20 11 32·6	+30 46 1		Slower variation.
7	21 6 15·0	+12 12 26	(1855).	A. G. Leipzig I.
8	21 14 7·5	+13 50 17	(1855).	Var. 9·1 to 12·5. Per ± 205^{d}
9	23 48·4	+52 55		

A variable in the position

15 32 42	−54 54·4	(1875).	Suspected by Kapteyn

has been confirmed at the Cape. Variation, 8·7 to 9·3 per $12^{d}\cdot68$.

The variability of Sawyer's *Algol* type variable B.D. +12° 3557 has been confirmed. Duration of normal light $17^{h}\ 28^{m}$; decrease occupies $1^{h}\ 58^{m}$; increase $1^{h}\ 55^{m}$. Variation, $7^{m}\cdot2$ to $7^{m}\cdot7$.

The period of Mme. Ceraski's 2nd *Algol* type variable has been

determined at Harvard as $6^d\ 0^h\ 8^m{\cdot}8$. This differs so slightly from 6^d that for a long time the minima cannot be observed in certain longitudes. Observations were not obtainable in America before this year. Professor Pickering points out that this and four other stars of the Algol type, viz. *S Cancri*, *U Cephei*, *W Delphini*, and $+45°$ 3062 are especially interesting owing to the large variation in light, amounting to about 2 magnitudes in each case.

Sir Cuthbert Peek continues his observations at Rousdon Observatory. During the year 1899 17 maxima and 22 minima were observed; the total during the progress of this line of research being 245 maxima and 214 minima. The stars observed are mostly circumpolar, so that the light fluctuations are watched continuously through the star's period from maximum to maximum.

Every worker in the variable stars will hail with satisfaction an authoritative work giving a map of the vicinity of each well-known variable and a list of magnitudes of the comparison stars. Such a work is now in course of publication, in the shape of *Atlas Stellarum Variabilium*, by Father Hagen, S.J., of the Georgetown College Observatory, U.S.A.

The first three series of this atlas contain charts for stars between 0° and 115° polar distance, whose minimum brightness is beyond the reach of a 3-inch telescope. Series I., II., and III. have been published. Series IV. and V. will include stars whose range of variation can be followed respectively by a 3-inch telescope, and by the naked eye. The magnitudes of the atlas are computed from steps, and made to agree with the Bonn D.M. They can be connected with the photometric scale as soon as Professor Pickering shall have worked out his scheme of standard magnitudes of faint stars. The beauty and delicacy of the maps already published and the great convenience of having them on loose sheets will render the work indispensable to all workers in this line, and its completion will be looked forward to with very great interest.

It may be noted that the *Revised Harvard Photometry* of Professor Pickering contains the photometric magnitudes of some hundreds of comparison stars for variables.

Vol. xxxiii. of the *Annals of Harvard Observatory* contains the reduction of many thousands of observations of variable stars by Argelander, Schönfeld, and Schmidt.

Father Hagen has drawn attention to the MSS. of the late N. R. Pogson, relating to his proposed *Atlas of Variable Stars* (see *Monthly Notices*, vol. lix., p. 57). These comprise elaborate catalogues of comparison stars for a large number of variables and some charts. It does not seem likely these MSS. (which are deposited in *H. C. Obs.*) will appear in print just now in view of the above-mentioned atlas at present in course of publication; but the quality of Pogson's work seems so

good that no doubt it will be published later, when it can be usefully compared with the *Atlas Stell. Var.* E. E. M.

Stellar Spectroscopy in 1900.

New Star.—Professor E. C. Pickering announced in 1900 July that a new star had been discovered in *Aquila* by Mrs. Fleming in the course of her examination of the Draper Memorial photographs. The Harvard photographs show that it was not visible on 96 plates taken between 1886 August 21 and 1898 November 1. It appears, however, on 1899 April 21 as a star of 7th magnitude, and on 1899 October 27 as a star of 10th magnitude. Its spectrum on 1899 July 3 resembled those of other new stars, and on 1899 October 27 it had the characteristics of the spectrum of a gaseous nebula.

Professor Campbell, of the Lick Observatory, made visual observations of the spectrum on 1900 August 27, and found that it consisted of extremely faint continuous light in the green, and three bright bands in the positions of the three principal nebular lines; the bands were very broad (*Astroph. Jour.* xii. 258).

Chemistry of Stars.—Professor W. N. Hartley calls attention (*Astroph. Jour.* xi. 163) to the fact that the lines 4172, 4033± found in stars such as *γ Cygni*, *γ Orionis*, *α Orionis*, *α Cygni*, &c. coincide closely with lines 4172·214, 4033·112, found in the spectrum of *Gallium*. These lines are found also in the solar spectrum and probably also in the chromosphere.

Classification of Stars.—Sir Norman Lockyer contributes a paper on stars of Secchi's Type IV., under the title "The Piscian Stars" (*Proc. R. S.* lxvi. 126), dealing with suggestions of subdivision of the group of stars, which Dunér has specially studied. Lockyer regards the stars of this class as exhibiting signs of an advanced stage in cooling, and searches for evidence of variation from the average spectrum that would support the view that different individuals in this class may be further on in the process of cooling to extinction than others. Starting from the faint appearance of dark carbon flutings in the solar spectrum, and of solar lines in the "Piscian" stars, he is led to divide Dunér's class into seven species, and to regard the changes observed as indicating a gradual fall in temperature. Lockyer accepts the evidence gathered by McClean and Hale as to the dark lines other than flutings, but hesitates to admit the presence of bright lines which Hale has recorded.

Velocity in the Line of Sight.—A noteworthy result in the work of the past year is that many stars are found to have variable velocity. Professor Vogel calls attention to this in the interesting summary which he has published (*Sitz. ber. Berlin Akad.* 1900, xx. 373), dealing with the progress made in the last decade in the determination of stellar motions in the line of sight. A translation of his paper appears in *Astroph. Jour.* xi. 373.

A list of forty-two stars with variable velocity, many of them being now recognised as binary or multiple systems, is here given :—

Star.	Period.	Discoverer.	Date of Discovery.	Remarks.	References.
α Virginis	$4^{d}\cdot013$	Vogel	1889	Dark companion	*A. N.* **125**, 305. *Pots. Obs.* vii. 127.
β Persei	...	„	1889	Variable	*A. N.* **123**, 289. *Pots. Obs.* vii.
ζ Ursæ Majoris	...	Pickering	1889	Two bright stars	*Amer. Jour. Sci.* xxxix. 46.
β Aurigæ	...	Miss A. C. Maury	1891	„ „	4th Report of Draper Memorial, 1890.
β Lyræ	...	Pickering Belopolsky	1891 1892	Variable ...	*A. N.* **128**, 39. „ **131**, 139.
β Orionis	...	Vogel	1892?	...	*Pots. Obs.* vii. 146.
δ Cephei	$5^{d}\cdot375$	Belopolsky	1894	Variable	*A. N.* **136**, 281. „ **140**, 17.
μ_1 Scorpii	$1^{d}\cdot46$	Bailey	1895	Two bright stars	„ **142**, 11.
V Puppis	$3^{d}\cdot114$	Pickering	1895	Lacaille, 3105 Cord. G. C. 10534	„ **142**, 107.
η Aquilæ	$7^{d}\cdot176$	Belopolsky	1895	Variable	*Astroph. Jour.* vi. 393. Wright, *Astroph. Jour.* ix. 59.
α_1 Geminorum	$2^{d}\cdot93$	„	1896	Fainter component of Castor	*Bull. Acad. St. Pet.* iv. 341. *Astroph. Jour.* v. 1. *Mem. Spettr. Ital.* **26**. „ „ **28**.
λ Tauri	$3^{d}\cdot91$	„	1897	Variable	*A. N.* **145**, 281.
ζ Geminorum	$5^{d}\cdot375$	Belopolsky Campbell	1898 1899	... ...	„ **149**, 239. *Astroph. Jour.* ix. 86.
β Lupi	...	Mrs. Fleming	1898	...	*Harv. Obs. Circular*, 21. *A. N.* **145**, 271.
η Pegasi	$2\frac{1}{4}$ years	Campbell	1898	...	*Astroph. Jour.* viii. 159, 293. Belopolsky, *A. N.* **148**, 127.
o Leonis	$14\frac{1}{2}$ days	„	1898	In Miss Maury's list of composite spectra	*Astroph. Jour.* viii. 292, 293.
χ Draconis	$9\frac{1}{3}$ months	„	1898	...	*Astroph. Jour.* viii. 293.
θ Ursæ Majoris	5–7 days	Belopolsky	1899	...	*A. N.* **148**, 331. „ **151**, 39.
ι Pegasi	...	Campbell	1899	...	*Astroph. Jour.* ix. 310. Belopolsky, *A. N.* **154**, 210
θ Draconis	...	„	1899	...	*Astroph. Jour.* ix. 311.
α Aurigæ	104 days	Campbell Newall	1899	...	„ „ x. 177. *Monthly Notices*, R.A.S. lx. 418.

Star.	Period.	Discoverer.	Date of Discovery.	Remarks.	References.
ϵ Libræ	Several months	Campbell	1899	...	*Astroph. Jour.* x. 178.
h Draconis	...	,,	1899	...	,, ,, ,,
λ Andromedæ	19·2 days	,,	1899	...	,, ,, ,,
ϵ Ursæ Majoris	...	,,	1899	...	,, ,, ,,
ω Draconis	...	,,	1899	...	,, ,, ,,
α Ursæ Minoris	3·95 days	,,	1899	...	,, ,, x. 180. Frost, *Astroph. Jour.* x. 184. Belopolsky, *A. N.* 152, 199. Vogel, *Sitzb. Berlin Akad.* xx. 388.
β Capricorni	...	,,	1899	In Miss Maury's list of composite spectra	*Astroph. Jour.* x. 241.
v Sagittarii	...	,,	1899	...	,, ,, ,,
β Herculis	...	,,	1900	...	,, ,, xi. 140.
ϵ Leonis	...	W. S. Adams	1900	...	,, ,, xi. 307. Wright, *Astroph. Jour.* xi. 414.
12 Persei	...	Campbell	1900	...	*Astroph. Jour.* xii. 254.
ξ Ursæ Majoris	...	Wright	1900	Brighter star of telescopic binary	,, ,, ,,
93 Leonis	...	Campbell	1900	...	,, ,, ,,
β Scuti	...	Wright	1900	...	,, ,, ,,
d Boötis	...	,,	1900	...	,, ,, ,,
113 Herculis	...	,,	1900	...	,, ,, ,,
2 Scuti	...	,,	1900	...	,, ,, ,,
η Andromedæ	...	Campbell	1900	...	,, ,, ,,
κ Pegasi	6 days	,,	1900	One component of Burnham's binary. Dark companion	,, ,, xii. 256.
δ Orionis	1^{d}·92	Deslandres	1900	...	*C. R.* cxxx.
α Persei	...	Newall	1900	...	*Monthly Notices*, lxi. 12. Vogel, *Sitz. ber. Berlin Akad.* 1901, p. 51.

Reduction of Observations.—In an interesting note (*A. N.*, Bd. 152, 65) Dr. K. Schwarzschild deals with a new method of determining orbits for spectroscopic binaries. It is an extension and simplification of the method suggested by Lehmann-Filhés (*A. N.*, Bd. 136, 17), avoiding the troublesome operations of mechanical quadrature of the velocity-time curve derived from spectroscopic observations.

New Instruments.—A new refractor, with an aperture of $31\frac{1}{2}$ inches, has been set up at the Potsdam Observatory. Professor Vogel describes briefly (*Astroph. Jour.* xi. 393) two of the spectrographs which have been constructed for use with this equatorial. The more powerful has three flint prisms each of angle 63° 27′, and transmits a beam of which the diameter is $1\frac{1}{4}$ inch. The single-prism instrument transmits a beam 1·4 inch in diameter, and has one prism of refracting angle 60°.

Dr. Hartmann gives (*Zeitschr. f. Inst. Kunde*, xx., translated *Astroph. Jour.* xi. p. 400, and xii. p. 30) a valuable discussion of various points connected with the construction and adjustment of spectrographs in special reference to instruments to be used in connection with the new Potsdam refractor. He compares efficiency of simple and compound prisms, and concludes that only simple prisms should be used in stellar spectrographs. He deals with various methods of adjustment, and concludes his paper by describing a very ingenious diaphragm for covering the slit of a spectrograph. H. F. N.

The Figure of the Moon.

It was first pointed out by Newton that if the Moon were originally fluid, the tide raised by the Earth should have caused the diameter directed towards us to be longer than one at right angles to it, by an amount which he computed to be 186 feet. Lagrange noticed further, that in consequence of the Moon's rotation there should be a slight polar compression, and hence that the figure of the Moon should approximate to an ellipsoid with its least axis perpendicular to the plane of the equator, and its longest directed towards the Earth. The difference of the axes was so small that there seemed but little chance of its being detected by direct observation ; but that the true figure of the Moon is of this form, or at all events that the distribution of mass is such as to give moments of inertia which would correspond to such a figure, is shown both by the existence of a real physical libration, and also by the coincidence of the descending node of the lunar equator with the ascending node of the orbit.

A computation of the tide raised on the Moon, using data given by Laplace, shows the height to be nearly 130 metres, which is greater than Newton's result, but still very small, the difference between high and low tide being less than $\frac{1}{6000}$ of the Moon's radius.

The amount of the physical libration depends upon the ratios of the moments of inertia about the three principal axes, and when these are known the lengths of the axes of the corresponding homogeneous ellipsoid may be computed. Using the values of these ratios which he found from his discussion of Schlüter's observations, Dr. Franz finds that the ratio of the axes should

be 1·0003 : 1 : 0·9997. It was, however, shown by Laplace (*Méc. Cél.* Bk. V. ch. ii. § 18) that the Moon is not homogeneous, and that its figure is different from that which it would assume if it were wholly fluid, so that these results must be considered as not indicating more than the order of magnitude of the ratios to be determined.

The principal direct contributions to the problem have been those of Hansen (*R.A.S. Memoirs*, vol. xxiv.), who, from discordances between the observed and computed longitudes of the Moon, inferred that its centre of figure was 59 kilometres nearer to us than its centre of gravity, and of Gussew (*Bulletin of St. Petersburg Academy*, 1859 October 14), who from measures made on two of De la Rue's photographs, found an elongation towards the Earth of 5·5 per cent. These measures were undertaken at the suggestion of Hansen, and the result lends support to his theory, but is altogether discordant with the estimates derived from the height of the tide and from the physical libration.

Hansen's conclusions were disputed by Newcomb (*Proc. Am. Ass. for the Advancement of Science*, 1868, and *Am. Journal of Science and Arts*, 1868), who was supported by Delaunay at the sitting of the Paris Academy, 1870 January 10, but were defended by their author (*Ber. der Sächs. Gesel. der Wiss., Math.-Phys. Klasse*, Band 23).

Here the question remained until it was taken up by Dr. Franz, who in vol. xxxviii. of the *Königsberg Observations* publishes an account of a series of very careful measures made on five negatives, all taken at the Lick Observatory near the time of full Moon.

As a preliminary to his inquiry, and in order to determine the constants of his plates, Dr. Franz made extended series of heliometer measures of the distances of eight standard points from Mösting A, the position assumed for which was that derived from his discussion of Schlüter's observations, viz. :—

$$\lambda = -5^\circ\ 10'{\cdot}32 \pm 0'{\cdot}13, \qquad \beta = -3^\circ\ 11'{\cdot}40 \pm 0'{\cdot}09.$$

The following resulting places form not the least valuable part of Dr. Franz's work : —

Proclus ...	$\lambda = +4^\circ\ 57'{\cdot}27 \pm 0'{\cdot}57$	$\beta = +1^\circ\ 4'{\cdot}78 \pm 0'{\cdot}73$
Macrobius *a*...	$+40\ 21{\cdot}94 \pm 0{\cdot}52$	$+19\ 32{\cdot}69 \pm 0{\cdot}74$
Sharp A ...	$-42\ 33{\cdot}24 \pm 1{\cdot}40$	$+47\ 31{\cdot}78 \pm 0{\cdot}76$
Aristarchus...	$-47\ 32{\cdot}43 \pm 0{\cdot}86$	$+23\ 42{\cdot}23 \pm 0{\cdot}80$
Gassendi *z* ...	$-42\ 52{\cdot}19 \pm 0{\cdot}58$	$-16\ 27{\cdot}43 \pm 0{\cdot}55$
Byrgius A ...	$-63\ 48{\cdot}23 \pm 1{\cdot}32$	$-24\ 33{\cdot}47 \pm 0{\cdot}75$
Nicolai A ...	$+23\ 38{\cdot}92 \pm 0{\cdot}51$	$-42\ 26{\cdot}97 \pm 0{\cdot}63$
Fabricius K...	$+42\ 14{\cdot}63 \pm 0{\cdot}76$	$-46\ 4{\cdot}17 \pm 0{\cdot}86$

The probable errors are those resulting from the discordances of the individual measures; the places would be systematically affected by whatever real error there may be in the position of Mösting A, but, as Dr. Franz remarks, they are of a much higher order of accuracy than those found by measures from the limb.

These positions were used for determining the scale and orientation of the plates, as well as for testing them for any possible deformation due either to optical distortion or to contraction of the film. It was found that errors due to this cause were less than those of observation, the mean error of setting on a crater being 0·013 mm., or about 0″·19.

The values of the photographic irradiation for the different plates were found by measuring 7 points on the limb, and comparing the resulting diameter with that computed in accordance with the scale as previously found. The results obtained were +1″·55, +1″·30, +0″·73, +1″·06, −0″·11. In the last plate it was certainly small, the negative result being attributed to irregularities on the limb.

If two photographs of the Moon, taken under different librations, are compared, the effect due to change of libration will be equivalent to a rotation about an axis at right angles to the plane which passes through the two points on the surface which appear respectively as the centres of the discs, and through the centre of the ellipsoid which most nearly represents the figure of the Moon. When the librations are computed the amount of this rotation is known. If a system of longitude and latitude is constructed for which this plane forms the equator, then the effect of the rotation will be to cause an apparent change in the longitude of any point on the surface, its latitude remaining unaltered. The corresponding linear displacement of the image on the photograph will depend upon the distance of the point on the Moon's surface from the axis of rotation, in such a way that when one of the two is known the other can be determined. This linear displacement will have a maximum in the equator, and it is by measuring its value for points, on or near the equators corresponding to different combinations of his five photographs, that Dr. Franz has endeavoured to determine the elongation of the Moon towards the Earth. Seven combinations gave corresponding rotations varying from 10° to 14°. The other three combinations were not employed as the differences of libration were too small.

The principal cause of error encountered was in the difficulty of setting on the Moon's limb in order to determine the coordinates of the centre of the disc. The result has been to cause points measured in the same combination to appear systematically too near to or too far from the axis of rotation, and for two combinations the elongation comes out negative. The final result is

$$\frac{r_1 - r}{r} = +0{\cdot}00114 \pm 0{\cdot}00390$$

where the figure of the Moon is supposed to be a prolate spheroid with its longest axis r_1 directed towards the Earth, r being the length of an axis at right angles to this. From this Dr. Franz concludes that the Moon is sensibly spherical, in agreement with the results derived from the theory of tides and from the physical libration, and in opposition to that obtained by Gussew.

In discussing Gussew's observations Dr. Franz calls attention to the fact that he knew only the days on which his photographs were taken. He applied to De la Rue, but was unable to ascertain the exact times, which therefore he had to estimate from the longitudes of the terminators. If we make the supposition that the photographs were taken on the meridian, the times would differ from those assumed by $2^h\ 31^m$ and by 37^m respectively. In this case Gussew's value of the elongation would be reduced by about one half, and it would be possible to find times such that the resulting elongation should vanish altogether. Very little weight therefore is to be attached to his determination.

Dr. Franz has further applied his measures to the problem of finding the altitudes of different parts of the surface above the mean level. When the same point has been measured three or four times the discordances are such as to show that very little reliance can be placed upon the separate determinations, but the grouping of the positive and negative results shows that the northern hemisphere, and especially the north-east quadrant, containing the Oceanus Procellarum, lies the lowest; whilst the southern hemisphere, and especially the mountainous south-west quadrant, is the highest. He gives a coloured contour map constructed in accordance with his measures. S. A. S.

Solar Parallax from Transit of Venus Observations.

In the *Comptes Rendus* of 1899 December 11 M. Bouquet de la Grye has published the results of his discussion of the visual observations of the ten expeditions sent out by the French Academy of Sciences to observe the transit of *Venus* of 1882, with a promise that the results from the measurement of the photographs taken at the same time is to follow shortly. The chief causes that led to a modification of the previous provisional results published in 1884 were the interpretation of the times of contact by the various observers, the rejection of observations made with a double refraction prism placed before the eyepiece (because this apparently diminished the Sun's diameter, and therefore retarded the time of observed second contact and accelerated that of third contact by some 10^s), an allowance for the fact that the object-glasses were lightly silvered over so as to diminish the risk of cracking the coloured eye-shades, and, lastly, more accurate data for the value of the longitudes of the

different stations. These ten different expeditions all occupied stations either in North or South America, the most northerly and southerly of which were separated by 85° of latitude, while the most eastern and western were hardly 3° of longitude apart. The best determination of the solar parallax was therefore to be derived by Halley's method from observation of second and third contact. Eight observers in the northern hemisphere and nine in the southern made the necessary observations, and of these observers five in the northern and three in the southern hemisphere had object-glasses of eight inches aperture. As a matter of curiosity M. Bouquet de la Grye has determined the solar parallax by Halley's method from observations of first and fourth contact, but the individual results, as might be expected, prove to be not very accordant. For the treatment of the observations by Delisle's method, which requires observations of one contact at two stations as far apart as possible in longitude, the available material are as follows: Observations of second contact, 10 at stations south, 12 at stations north, of the equator; observation of third contact, 12 at stations south, 8 at stations north, of the equator. Finally, M. Bouquet de la Grye gives us the definitive result from the French visual observations the value 8″·80 for the solar parallax. The results of the different methods of treatment are as follows:—

Halley's Method.	Solar Parallax.
2nd and 3rd contacts (all instruments)	8″·8068
„ „ „ (8-inch aperture only)	8·7996
1st and 4th „	8·783
Delisle's Method.	
2nd contact, at stations 10 south, 12 north, of equator	8·772
3rd „ „ 12 „ 8 „ „	8·788

W. G. T.

Researches on Stellar Parallax made with the Cape Heliometer.

In vol. viii. pt. ii. of the *Annals of the Royal Observatory Cape of Good Hope*, Sir David Gill publishes the results of his observations of stellar parallax in the southern hemisphere made since 1887. This may, to some extent, be considered as a continuation and extension of his earlier work in the same field published in the *Memoirs of the R.A.S.* vol. xlviii. It is, however, of a still higher order of accuracy, and those who have appreciated the value of the earlier series will find here fresh cause to admire the energy and skill which have gone towards the acquisition of these remarkable results.

The measures were made with the new 7-inch heliometer constructed by Messrs. Repsold, Sir David Gill himself, and Messrs. Finlay, de Sitter, and Lowinger taking part in the observations.

A description of the instrument and mode of using it is given in vol. vii. of the same series of annals. This instrument is so greatly superior to the 4-inch heliometer, with which the former results were obtained that Sir David Gill estimates its efficiency as being six times that of its predecessor.

Needless to say, every precaution which previous experience suggested has here been adopted to avoid systematic error in the measures, and it is an agreeable feature of these results that there appears to be no necessity for the application of systematic corrections such as had to be introduced into some of the earlier investigations. In this connexion it may, perhaps, be permitted to express a regret that the parallax of *α Centauri*, which was especially affected by such errors, has not been subjected to a renewed attack with this more powerful instrument, as was done in the case of *Canopus*, *Sirius*, and *β Centauri*.

Sir David Gill has investigated at some length the effect of the chromatic dispersion of the atmosphere upon his results. It is a little unfortunate, perhaps, that the observations were so arranged that in nearly every case the factors for $\Delta\beta$ (the atmospheric dispersion) run almost parallel with those of the parallax, so that the two cannot be separated ; but the measures of *δ Sagittarii*—a remarkably red star—made by Messrs. de Sitter and Lowinger, and those of *β Orionis*, made by Sir David Gill himself, seem to show that in these measures the effect of atmospheric dispersion is probably insignificant.

The resulting stellar parallaxes published in this volume are :—

Star.	Mag.	Parallax.	Prob. Error.
		″	″
Sirius	−1·8	0·370	±0·010
Canopus	−1·0	0·000	±0·010
Rigel	0·35	0·000	±0·010
Achernar	0·5	0·043	±0·015
β Centauri	0·8	0·046	±0·017
α Crucis	1·0	0·050	±0·019
Spica	1·2	−0·019	±0·010
Fomalhaut	1·3	0·130	±0·014
α Scorpii	1·3	0·021	±0·012
β Crucis	1·5	0·000	±0·008
α Gruis	1·9	0·015	±0·007
β Hydri	2·9	0·134	±0·007
τ Ceti	3·6	0·310	±0·012
Lacaille 2957	6·0	0·064	±0·024
P. xiv. 212	A 6·3 B 7·9	0·167	±0·008
Z.C. V. 243	8·5	0·312	±0·016

Tables giving, on different assumptions as to the parallaxes of the comparison stars, the light energy of those stars whose *apparent* parallaxes have been determined compared with the light energy of the Sun, and their velocity at right angles to the line of sight, as well as an appendix containing "Auxiliary Tables to facilitate the Selection of Comparison Stars and the Computation of Factors of Stellar Parallax," complete a volume of the highest value and importance to astronomers. A. A. R.

Star Catalogues.

Greenwich Second Ten-Year Catalogue (1890·0). — It is satisfactory to find that the necessity for taking up various new lines of research has not diminished the activity of our national Observatory in meridian observation. The first Ten-Year Catalogue contained 4059 stars; the second, representing the work of an equal number of years, contains 6892—a notable advance in place of any falling off. And just as the increase in quantity is shown by these figures in the very name of the Catalogue, so the steady advance in accuracy is demonstrated by the diagram which forms the frontispiece. Nothing could be more instructive than the comparative curves for the 1860, 1864, 1872, 1880, and 1890 Catalogues, showing the gradual elimination of errors of a systematic kind in the right ascensions of the clock-stars, effected by the simple but drastic expedient of keeping for fundamental places only those observations which extend over a period of twelve hours at least. Other errors of a systematic kind, both in R.A. and N.P.D., have been fully discussed, though sometimes without reaching any conclusion; and again sometimes reaching a conclusion, but finding the corresponding correction too small to be applied. But a large amount of material is collected in the Introduction for those who may be fortunate enough to find from it the hitherto unsuspected clue to some source of error, or may wish to apply corrections which the Astronomer-Royal prefers to leave unapplied.

The most noteworthy discordance still unexplained is the well-known R—D discordance. It has, among other peculiarities, suddenly disappeared, but this was after the conclusion of the observations forming the Catalogue. In 1893–4 it was hoped that some light had been thrown on the nature of this puzzling phenomenon from the discovery that when the D observation was made before the R, instead of afterwards, the discordance changed sign; but another kind of experiment (taking the R and D observations on separate nights) gives results which it is difficult to reconcile with the former, so that matters are much as they were. Another unexplained discordance is that between the nadir observation and the reflexion observations of stars.

Of systematic errors detected, but not allowed for, the most novel are the diurnal variations in the level, azimuth, and nadir-point. The maxima seem to occur about noon and midnight,

and the minima about 6 A.M. and 6 P.M., though the distinction between maximum and minimum is of course arbitrary. Again, the solar observations indicate an equinox correction of about $+0^{s}\cdot05$, which would make the Catalogue agree better with Newcomb's Fundamental Catalogue; but "no correction has been applied, as the uncertainty of the system of proper motions based on Bradley's equinox, and of the observations of the Sun due to the personality of the observers, leaves the determination of the equinox somewhat arbitrary. The equinox of the Catalogue therefore is that of the 1872 Catalogue carried on by the use of Struve-Peters' precessions and Auwers'-Bradley proper motions."

Of errors detected and applied a conspicuous example is afforded by the new division-errors of the circle, which have removed a long known anomaly near the pole.

Very complete discussions of refraction and colatitude, and of comparisons of the Catalogues with others, are given in the Introduction. The evidence is in favour of the Pulkowa refractions, and of a colatitude 38° 28′ 21″·80, or even 21″·75, instead of 21″·90 as before; but this does not, of course, mean a real change in latitude. Similar conclusions were reached by a discussion of the previous Ten-Year Catalogue (1880). There is, however, a conspicuous exception to the general trend of the evidence—the Pulkowa refractions do not suit the Sun observations at all well.

The comparisons with other Catalogues include a very complete set with those of the Catalogues of the *Astronomische Gesellschaft*, which should be of the greatest use in the work of the great Astrographic Catalogue. It is also to be remarked that the agreement with Newcomb's Fundamental Catalogue (when the epoch correction is made, and the Pulkowa refractions are used) is practically perfect.

The Catalogue contains a large number of stars well distributed over the northern hemisphere, and suitable for the elucidation of all sorts of systematic errors. But its main feature is the re-observation of 3645 of Groombridge's 4243 stars (1810); and naturally a valuable series of proper motions can be obtained. The largest of these, to the number of 174, are given, with full details, in the Introduction, and complete a fine piece of work in fundamental astronomy.

Cape Catalogue of 1905 *stars for* 1865·0.—The following significant words may be quoted *verbatim* from the Preface: "The publication of this Catalogue marks an epoch in the history of the Observatory. For the first time in that history the Director can feel that the accumulated labours of his predecessors are available for the use of Astronomers, and that the work being done under his own direction is in a healthy and forward state of reduction and publication."

The last of the arrears are thus wiped off in the present catalogue, which represents the meridian work of the years 1861–1870 under Sir Thomas Maclear. A comparison of the catalogue

with Newcomb's fundamental catalogue shows systematic differences in both co-ordinates depending on the declination, but nothing serious depending on R.A. Sir David Gill gives reasons, however, why the catalogue should not be regarded as a fundamental one. One of the reasons is a curious "apparent change of latitude between 1862 and 1863." The correction to adopted latitude (−33° 56′ 3″·20) shown by circumpolars in the year 1862 is −0″·27 ; in 1863 is −0″·67 ; and in subsequent years to 1870 is −0″·90 with small fluctuations. On this Sir David Gill remarks : "I have been unable to find any satisfactory explanation for the marked apparent change of latitude between 1862 and 1863." Referring to the annual results we find that the only instrumental change mentioned about this time is the insertion on 1862 July 28, of a pair of ZD wires at 14″ apart instead of the single one previously used. Nothing is said about the way in which the pair of wires was used, but it is noteworthy that if the latitude observations of the year 1862 be separated by the date just mentioned, the earlier group gives the correction −0″·43, agreeing nearly with the −0″·27 for 1861, and the later group the correction −1″·17, agreeing with 1863 and subsequent years. The curious change is thus possibly connected with this change of wires.

Catalogue of the Astronomische Gesellschaft.—The second half of the Leipzig work containing zones +10° to +15°, referred to in the last report as in the press, has since been published. It contains the places of 9547 stars, nearly all observed twice, and a large number of them oftener. The instrument was a 6-inch transit circle by Pistor and Martins ; and the observations were made chiefly by Drs. Engelmann and Bruhns in the years 1868 to 1873. For the declinations the general practice was to read only one microscope. A full account is given in the Introduction to this Catalogue of the work for both this zone and for Leipzig II (+5° to +10°), published last year.

A catalogue has also been published by the Lund Observatory of the places of the stars observed in zones +35° to +40°. The separate observations of each star are given separately ; and the stars are not numbered, so that the exact total is not apparent ; but there seem to be about 10,000 stars.

The Leiden Catalogue from +30° to +35° has been printed off with the exception of the Introduction, and may thus be expected shortly. This leaves only the Dorpat zone from +70° to +75° outstanding in the northern half of the *Gesellschaft Catalogue*. It is satisfactory to have the completion of so noble a work within sight. H. H. T.

The Cape Photographic and the Cordoba Durchmusterung.

The third and concluding volume of the *C. P. D.*, consisting of the zones from dec. −53° to the South Pole, and the

third volume of the *C. D.* embracing zones from dec. $-42°$ to $-52°$, have been published during the year. The *Cape Photographic Durchmusterung*, of which a brief account was given in the Council Report for 1897 on the appearance of the first volume, extends from dec. $-19°$ to the South Pole. It contains 454,875 stars, being an average of 32·66 to the square degree, and is considered by Dr. Kapteyn to be complete down to the magnitude 9·5 on the scales of Gould, Schönfeld and Thome in the neighbourhood of the Milky Way, and to reach the corresponding photographic magnitude in the rest of the sky. The limit of magnitude to which this survey reaches is stated in this form because Dr. Kapteyn concludes that the stars in the neighbourhood of the Milky Way are more photographically active than those in the rest of the sky. The right ascensions and declinations of the stars are obtained by using the stars observed by Gould in the *Cordoba Zone Catalogues* as reference stars, and the probable error of the deduced positions is about $\pm 2''\cdot 5$ for the right ascensions and about $\pm 3''\cdot 0$ for the declinations. The polar plate reaching to 5° from the South Pole has been measured with greater accuracy, the probable errors being $\pm 0''\cdot 53$ and $\pm 0''\cdot 76$ respectively. The magnitudes are deduced from the measured diameters of the star images by the formula $m = \frac{B}{C+d}$, where the constants B and C for each plate are obtained by comparison with the visual magnitudes given in Gould's *Zone Catalogues*. The number of stars used in obtaining the constants B and C generally lies between 70 and 130, and a large majority of these have the magnitudes 8·5, 9·0, and 9·5 in Gould's Catalogue. An extrapolation is necessary for the stars fainter than $9^{m}\cdot 5$ on Gould's scale.

An important feature of this *Durchmusterung* is the extensive manner in which it has been compared with other catalogues and surveys. For example, lists are given of stars of magnitudes 9·0 and brighter given in catalogues of precision and not shown on the plates. This part of the work is still in hand, and Sir David Gill and Dr. Kapteyn state their intention of publishing (*a*) lists of errors found in previous catalogues; (*b*) a list of large and previously unknown proper motions; (*c*) a list of new variables; (*d*) a more exhaustive investigation on the difference in colour between the stars near the Milky Way and the rest of the sky; and (*e*) a comprehensive discussion of photographic magnitudes.

The *Cordoba Durchmusterung*, of which a brief account was given on the publication of the first two volumes in the Council Report for 1894, is now completed from dec. $-22°$ to $-52°$, and the zone $-52°$ to $-62°$ is stated by Dr. Thome to be well advanced. In the part already published there are 489,662 stars, or an average of 57·5 per square degree, and Dr. Thome considers that it is complete to magnitude 10·0, and very nearly so to 10·2. The number of stars observed is much larger than the

number in the *C.P.D.*, but the positions of the stars are less accurate than in that work, the probable errors of the Right Ascensions ranging from $\pm 0^s.3$ for the brighter stars to $\pm 0^s.7$ for the faintest, and being $\pm 6''.0$ for the declinations. It is of interest to notice that comparison with the *C.P.D.* indicates a personal equation with magnitude of $+0^s.389$ for $9^m.4$ with a rate of $+0^s.037$ for each additional tenth.

The chief interest in a Durchmusterung, such as the *C.D.* or the *C.P.D.*, is not the accuracy of the positions, for which great precision is not attempted, but rather in questions relating to magnitude and distribution of the stars. Dr. Thome gives a long list of stars where the range in the observations of magnitude were so large as to lead him to suspect variability.

Naturally the Durchmusterung provides very ample material for studying the distribution of the stars. Dr. Thome gives counts of the stars for each degree of declination and 4^m of Right Ascension. On comparison with the *C.P.D.*, it appears that three times as many stars are shown by the *C.D.* in the sparse regions of the sky, but that in the richer regions of the Milky Way the *C.P.D.* shows more stars than the *C.D.* In the explanation of this interesting fact Dr. Thome and Dr. Kapteyn are at variance, the former attributing it to observational causes, and the latter to a real variation in the quality of the light of the stars near the Milky Way. Without entering into a discussion of this subject, it may be noted that the mere discovery of the fact is a striking instance of the value of making visual observations concurrently with photographic observations. Comparison of Dr. Thome's results with the *Cape Photographic Durchmusterung*, and in due course with the astrographic photographs, will furnish a very comprehensive comparison of visual and photographic magnitudes, and be of very great importance in all discussions of the distribution of the stars in the Southern Hemisphere. F. W. D.

A Universal Star Catalogue.

In the Annual Report on progress of work undertaken by the Berlin Academy of Sciences, presented at the meeting of January 24, 1901, Professor Auwers gave an account of a new astronomical undertaking, the object of which is to completely collect and exhaustively discuss all determinations of star places obtained by meridian observations at the various observatories during the period 1750–1900, and to form therefrom one General Catalogue of stars for the equinox 1875. This catalogue will contain the most probable positions, derived with due allowance for weights, for the middle epoch of the observations of each star, and the proper motions wherever the observations are sufficient for their determination.

The results of meridian determinations of star places are at

present scattered over more than three hundred different catalogues which are at the present time and will be for many years worthy of consideration in all work depending on accurate positions of stars or dealing with their proper motions. An immense amount of labour is wasted at present, as each astronomer engaged in such work has to collect for himself and consult (very frequently in vain) these many different sources, to bring up their dates to a common equinox, and then to derive the best possible place for the epoch he requires. And the difficulty of mastering a material already so enormously extended and widely scattered goes on increasing, and in all probability—without taking any account of the results of the new method of photographic observations, to be separately dealt with at some future epoch—increasing with the number of working observatories at an accelerated rate. The danger seems great, therefore, that complete acquaintance with existing star catalogues and the possibility of systematically handling them will before long generally be out of the reach of practical astronomers, with the effect that a limited number of catalogues will be selected for future reference, and the rest, though they contain results which will be of service for a long time to come, will be overlooked, and be practically useless.

To establish order within a department which is rapidly being filled with a nearly chaotic mass—to spare astronomers of the twentieth century unlimited waste of labour in incessant repetition of work which can be done once for all—to ensure to sidereal astronomy the permanent possession of all the riches gained by the combined efforts of observers and computers engaged in meridional work during the 150 years which sever the beginning of the twentieth century from the beginning of meridian work of precision—to transform the combined result of all of that work hitherto done into a ready and powerful means for progress—these are the objects of the Berlin Academy in undertaking a universal star catalogue.

The total number of published star places obtained by meridian observations since 1750 is estimated at about one million—excluding all publications of observatories which contain raw observations, or apparent places only—relating to about one-fourth that number of different stars. Considering the enormous extent of a work dealing with this whole mass, it was at first thought advisable to exclude the great zone catalogues, and to confine the collection and discussion to the large mass of special catalogues. It is mainly these that give rise to embarrassment, by their great number—and by scarceness of copies of many of them—and by the great variety of contents and different degrees of accuracy. On closer examination, however, it was found too difficult to draw a convenient line of separation between the catalogues to be included in the collective work and those to be left for special reference, and besides, any limitation would largely diminish the usefulness of the work and necessarily

leave much to be done afterwards. The only reasonable plan, therefore, from the scientific as well as from the economical point of view, clearly appeared to consist in framing the scheme of the work from the beginning on the broadest lines, and to include in it the complete history of every star observed during the last 150 years.

That the work may be really complete for this period, it now becomes extremely desirable that all those series of meridian observations of stars, which, at the present time, are accessible only under the form of observation journals or in an incomplete state of reduction, should be finally reduced and catalogued, where possible by the observatories to whom they belong. This must be done before the Berlin work shall have accomplished the first two of its steps, viz. (1) the collection and chronological arrangement of all published positions of every observed star, and (2) the bringing up of these positions, by precession, to 1875. It is expected that a pretty considerable number of years will be spent upon these parts of the work, so that there is still the possibility of a good deal of useful complementary work being done in the meantime, and of its results being inserted in the right place ; but when this stage of the work is once reached, it will be very difficult to introduce any more additions.

The Academy, after having secured, on the occasion of its bicentenary, celebrated in 1900, a permanent endowment for the work, has appointed Dr. F. Ristenpart as chief of the computing office established for the execution of the work, and has charged him with the execution of all the necessary detail under the general superintendence of an Academical Committee of which Professor Auwers is president.

Dr. Ristenpart, aided by repeated special grants out of academical funds before the Academy formally enrolled the "Geschichte des Fixsternhimmels" on the list of its own undertakings, has been at work since 1898, but on a more limited scale for the greater part of the period. During this period the collection and chronological arrangement of catalogued star places has been accomplished to the epoch 1842, and next the positions from Argelander's northern zones will be filled in on the cards. The total number of positions yielded by the catalogues whose epochs are between 1750 and 1842 is about 240,000 ; but there is hope that this number will be increased by 20,000 to 25,000 from some existing and probably valuable series of unreduced and unpublished but accessible observations.

[The Council is indebted to Dr. Auwers for this note.]

Professor Kapteyn's proposed Durchmusterung for Parallax.

In 1889 Professor Kapteyn proposed that each plate for the astrographic catalogue should be exposed at three successive epochs of maximum parallactic displacement, being carefully preserved in the intervals of six months, and developed after the

third series of exposures. The plates would then furnish, in addition to the positions of the stars, a first determination of their parallaxes. The proposal was not adopted for the catalogue work. But in 1891 Professor Donner undertook to obtain with the astrographic equatorial at Helsingfors a series of plates for a definitive trial of this method of obtaining parallaxes wholesale.

In 1895 Professor Kapteyn set up a Repsold measuring machine in a room which had been placed at his disposal in the physical laboratory at Groningen, and in the intervals which could be spared from his work on the *Cape Photographic Durchmusterung* he has measured and discussed three plates of a region in the Milky Way about the star B.D. $+35^\circ$ 4013, which includes three of the Wolf-Rayet stars. The preliminary results, in the form of a table of the measured parallaxes of 246 stars, were given in *A. N.*, No. 3475, and a full account of the work has just appeared in the first part of the *Publications of the Astronomical Laboratory at Groningen.*

Each star gives rise to an equation of condition of the form

$$v = a + bx + cy + dx^2 + exy + fy^2 + H\pi ;$$

where x, y are the rectangular coordinates of the star; v is a function, independent of the proper motion, of the measured distances between corresponding images; π is the parallax relative to the mean of all the stars on the plate; and the six constants a, b, c, d, e, f, include the effects of changes in orientation and scale value, differential refraction and aberration, and in the inclination of the plate to the optical axis.

The values of the six constants for the plate are obtained by an abbreviated least square solution, the term $H\pi$ in each equation of condition being treated for the time as if it were an accidental error.

The first important point made by Professor Kapteyn is that appreciable terms of the second order may arise from variation due to flexure of the tube in the inclination of the plate to the optical axis; moreover, the displacement given to the plate to secure a series of exposures is equivalent to an inclination, and the equivalent inclination must be kept much smaller than a minute of arc if parallaxes are to be determined all over a plate 2° square. It is therefore useless to compute separately the second order terms in refraction and aberration. The uncertainty in the determination from the measures of the three additional constants diminishes the weight of a parallax in the most unfavourable case by one-tenth only.

It seemed probable *à priori* that distortion of the film might occur during the six months intervals between the exposures. The parallaxes found were therefore divided into twenty-five groups, and means taken for each group on each plate. The numerical values of the means are distributed consistently with their being purely accidental. Professor Kapteyn concludes

that there is no systematic error depending on position, and that the film is not distorted during keeping. It may be considered that this point requires further examination, since on one plate the means have a distinct tendency to be of opposite signs on opposite halves of the plate.

A search for systematic error depending on magnitude leads to results of the highest importance. Personality in measurement has been completely eliminated by reversal. Yet the ten brightest stars have on one plate a mean parallax of $+0''{\cdot}092$; on the other plates of $+0''{\cdot}019$ and $+0''{\cdot}014$. Professor Kapteyn considers that this abnormal result on one plate is due to defective guiding, which has displaced the centre of gravity of the larger discs. In short exposures intended for accurate measurement, guiding by hand must be dispensed with.

If these anomalous results are rejected, and the others collected into magnitude groups, the means are

Mag. 10·2	$\pi = -0''{\cdot}009$
9·6	$- \quad {\cdot}004$
8·6	$+ \quad {\cdot}013$

Professor Kapteyn considers that the real difference of parallax for these groups must be much smaller. This opinion is based upon an investigation published in *A. N.* 3487. The mean parallaxes for the groups of fainter stars are there derived by extrapolation, the legitimacy of which is perhaps open to question. The greater part of the difference is attributed to "hour angle error," due to atmospheric dispersion. The plates were taken about hour angles 5^h E. and 3^h W.

To confirm this conclusion Professor Kapteyn examines the residuals in Dr. Wilsing's measures of the distance between the two components of 61 *Cygni* (*Publ. Astrophys. Obs. Potsdam*, vol. xi., No. 36). He concludes that they show very decided traces of the effects of dispersion. Dr. Wilsing considered the deviations in the distance due to orbital motion of one of the components. Dr. Herman Davis has also examined these residuals (*Rutherfurd Photographic Measures, Parallax of* 61 *Cygni*), and is inclined to attribute them to a real difference of parallax of the two components. A comparison of the solutions of Kapteyn and Davis shows that the effects of atmospheric dispersion and of a real difference of parallax run so nearly parallel that it is impossible to discriminate between them. As a numerical corroboration of Professor Kapteyn's proposition the argument therefore fails ; but the manner of its failure is itself the strongest proof of the truth of the proposition—Photographs for parallax must all be taken on the meridian, or, at least, in identical small hour angles.

This condition is not so completely prohibitive of parallax

determinations by photography as it may at first sight appear. But it requires generally that the plates shall be taken at some distance from the epochs of maximum parallactic displacement.

From a comparison of the measures made in reversed positions of the plate, the probable error of a parallax derived from one plate is $\pm 0''\cdot0155$; whereas a comparison *inter se* of the results from three plates gives for the same quantity $\pm 0''\cdot0315$. A number of investigations into the cause of this discrepancy lead to the conclusion that the agreement of successive pointings on one image is no criterion of the real accuracy of the measured position ; that the true P.E. of pointing on a single image, four settings in each of two positions of the plate, is $\pm 0''\cdot080$; and that consequently a single setting in each of two positions gives all the accuracy obtainable from a single plate. Finally, the real P.E. of a parallax derived from one plate is $\pm 0''\cdot035$.

On the basis of these results Professor Kapteyn discusses the possibility of a general Durchmusterung for parallax, to include all stars down to the 10th magnitude, about 800,000 in number. From the results of an unpublished investigation it is probable that 450 of these have a parallax $\geqq 0''\cdot10$. On the other hand, since the P.E. of a parallax derived from two plates is $\pm 0\cdot025$, the accumulation of accidental error would produce in 800,000 determinations some 6000 entirely spurious parallaxes $\geqq 0''\cdot10$. It would be necessary to take further plates to separate the true from the false. With an expenditure of two more plates on every star for which the first determination gave a parallax $\geqq 0''\cdot11$, about 500 real and well-determined parallaxes would eventually be obtained.

It is estimated that the total labour involved in the photographic work would be about equal to that expended on the chartand catalogue plates for the *Carte du Ciel* ; while the labour of measurement and reduction would not much exceed that required for the measurement of the catalogue series and their reduction to corrected rectangular coordinates.

Several reasons at once present themselves for regarding the first conclusion as much too hopeful. The most weighty of these is the consideration that, in the uncertain climates in which most astronomical work has to be done, the labour of obtaining results at strictly limited seasons of the year and hours of the night—half of them very late hours is beyond comparison more severe than straightforward labour on the astrographic chart.

There is, however, nothing to discourage at least a great extension of work on the lines which Professor Kapteyn has laid down ; and there is every reason to hope that as the accuracy of the work will surely gradually increase, the large proportion of spurious parallaxes obtained will diminish.

In conclusion it may be permitted to congratulate Professor Kapteyn on the foundation of an astronomical laboratory and a school of practical astronomy in a university which possesses no

observatory, in the hitherto accepted sense of the word. It is a great step towards generating the power required to deal with the mass of material superabundantly produced by existing photographic telescopes. A. R. H.

The Astrographic Chart.

The fourth meeting of the Permanent Committee, which, if the initial meeting be included, was the fifth conference on the Astrographic Chart, was held in Paris in July. Directors of twelve * out of the eighteen participating Observatories attended, the absentees being the representatives of Helsingfors (through ill-health), Sydney, Melbourne, Santiago de Chile, La Plata, Rio de Janeiro. The three last named observatories appear to have abandoned the work, and the offers of Dr. Thome of Cordoba, and M. Enrique Legrand, representing an observatory which is to be established in Monte Video, to undertake the zones allotted to these observatories were received by the Committee. It is understood that Mr. Cooke, of the Perth Observatory, West Australia, has since agreed to take a share in the work, so that the following table shows the present arrangement of the zones and the progress in each at date 1900 June.

	Zone.	Number of fields assigned.	Number taken for cat.	Number taken for chart.	Number of cat. plates measured.
Greenwich	+90° to +65°	1149	1106	1076	608
Rome	+64 ,, +55	1140	476	106	15
Catania	+54 ,, +47	1008	1008	...	36
Helsingfors	+46 ,, +40	1008	1008		380
Potsdam	+39 ,, +32	1232	1232	...	250
Oxford	+31 ,, +25	1180	736	...	736
Paris	+24 ,, +18	1260	1260	97	650
Bordeaux	+17 ,, +11	1260	402	17	293
Toulouse	+10 ,, + 5	1080	540	45	135
Algiers	+ 4 ,, − 2	1260	1260	56	497
San Fernando ...	− 3 ,, − 9	1260	1260	664	145
Tacubaya	−10 ,, −16	1260	746	...	203
Monte Video ...	−17 ,, −23	1260	...	...	...
Cordoba	−24 ,, −31	1360	...	...	...
Perth	−32 ,, −40	1376	...	...	...
Cape of Good Hope	−41 ,, −51	1512	1512	1134	106
Sydney	−52 ,, −64	1400	1400		
Melbourne	−65 ,, −90	1149	900	575	

* M. Vallé, who has lately succeeded to the Directorship of the Tacubaya Observatory, was present, as well as his predecessor M. Anguiano. Neither he, nor Dr. Thome, nor M. Legrand are included in this number. H. P. H.

The chart plates taken at Paris, Bordeaux, Toulouse and Algiers are being reproduced on an enlarged scale by heliogravure, and the numbers given for these observatories in column 5 of the above table refer to these reproductions; negatives of many other fields have been taken. The measurement of the catalogue plates taken at Sydney and Melbourne is being actively carried on at the Melbourne Observatory, but the number measured at the date to which the table refers is not to hand. At the end of the year 1899, 42 of the plates had been measured.

The substance of the chief resolution of the Conference is that it is not necessary that equatorial coordinates for all the stars should be given in the *Astrographic Catalogue*. It will be sufficient if it contains the measured rectangular coordinates of the stars with sufficient data to convert these into standard coordinates. Supplementary appendices or introduction can be be added as may be thought necessary. The printing of the *Greenwich Catalogue* on these lines is proceeding, and nearly a quarter of the whole work is in type. The *Paris Catalogue* is being printed in a very similar form. As to the publication of the *Chart*, it was resolved that copies on paper of the plates should be made, but no agreement as to the method was arrived at.

The Conference also discussed methods of measuring the diameters of the star images and also the length and method of exposure of the chart plates. It may be remembered that it had been resolved previously that half of these should be taken with three exposures of thirty minutes each, the others with one exposure of forty minutes. The procedure in both these matters was left to individual discretion.

Some papers relating to the subject have appeared in the Notices of the Society during the year. H. P. H.

Universal Time.

During the year two countries have been added to the number of those whose legal time depends on the meridian of Greenwich. Since October 1 Eastern-European Time, two hours fast on Greenwich, has been in use in Egypt, and the time-balls at Alexandria and Port Said have been dropped according to this. From 1901 January 1, Greenwich time has been the legal time in Spain, and the hours in this country are to be counted from 1 to 24, the day beginning at midnight.

It may be added that the Paris Bureau des Longitudes made a similar change in the *Annuaire* for 1900, and the words *matin* and *soir* no longer appear in that publication, but all times are described as *moyenne civile*. H. P. H.

The Cataloguing of Astronomical Literature.

On the initiative of the Royal Society, an International Conference was held in London in 1896 to consider the indexing of scientific literature. A resolution was carried, "That it is desirable to compile and publish, by means of some International organisation, a complete Catalogue of Scientific Literature, arranged according both to subject-matter and to author's names."

The Royal Society, later in the same year, appointed a committee to study all questions relating to the projected Catalogue, and two further International Conferences were held for the same purpose in 1898 and 1900. The difficulties attending the inception of this gigantic work seem now to have been overcome, and it is definitely settled that the Catalogue shall include all scientific literature published subsequently to 1901 January 1, and that publication shall commence with the volumes for the current year. Seventeen volumes are to be published annually, of which one will be devoted to astronomy, one to mathematics, one to botany, etc. ; it is expected that they will contain an aggregate of 160,000 entries per annum. The materials out of which the Catalogue is formed are furnished to a Central Bureau in London by bodies termed Regional Bureaux, of which one is being established in every civilised nation. In this country the work of the Regional Bureau will be done by the learned societies, the Council of the R.A.S. having undertaken the work of furnishing slips for all the astronomical literature published in the United Kingdom.

The new *Astronomischer Jahresbericht*, edited by Dr. W. F. Wislicenus under the auspices of the *Astronomische Gesellschaft*, though very different in plan from the Catalogue, is largely designed to meet the same need. In an annual volume of about 500 pages, the astronomical papers published during the year preceding are briefly reviewed. The general arrangement is similar to that of the *Jahrbuch über die Fortschritte der Mathematik*, and the one publication will probably be found as useful to the astronomer as the other has long been to the mathematician.

E. T. W.

Papers read before the Society from March 1900 to January 1901.

1900.

Mar. 9. Observations of the *Leonids*, 1899. C. Michie Smith.
Photographic observations of Hind's variable Nebula in *Taurus*, made with the Crossley reflector of the Lick Observatory. J. E. Keeler.
Ephemeris for physical observations of the Moon for the second half of 1900. A. C. D. Crommelin.
Note on a possible occultation of *A Geminorum* by *Venus*, 1900 May 27–28. W. W. Bryant.
The maximum duration possible for a total solar eclipse. C. T. Whitmell.
The use of a coloured screen in photographing the corona during an eclipse. W. Shackleton.
On a simple method of comparing the Bonn Durchmusterung with photographic plates. H. H. Turner.
Graphical method for the determination of the local times of contact in a solar eclipse. F. C. Penrose.
Observations of *Saturn* made at Juvisy Observatory in 1899. C. Flammarion.

Apr. 11. On stationary radiants of meteors : reply to the criticisms of M. Brédikhine. H. H. Turner.
On the binary system of *Capella*. H. F. Newall.
Observations of spots and markings on the planet *Jupiter* made at the Dearborn Observatory of North-Western University, Evanston, U.S.A. G. W. Hough.
On the orbit of β 883. T. Lewis.
The effects of stellar rotation upon spectrum lines. A. Fowler.
The equatorial current of *Jupiter* in 1898. A. Stanley Williams.
On the alleged rotation of the spiral nebula *Messier* 51, *Canum Venaticorum*. H. H. Turner.
Observations of the *Leonids* made at the Cambridge Observatory on 1899 November 13, 14, 15. A. R. Hinks.
Measures of double stars from photographs taken with the 26-inch refractor of the Thompson equatorial at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

1900.

April 11. Cometary observations at the Liverpool Observatory. W. E. Plummer.

An application of projective geometry to binary star orbits. H. C. Plummer.

Results of micrometer measures of double stars made with the 28-inch refractor at the Royal Observatory, Greenwich, in the year 1899. Communicated by the Astronomer Royal.

May 11. Observations of Minor Planets at Windsor, New South Wales. John Tebbutt.

The duration of the greater Sun-spot disturbances for the years 1881–99. Rev. A. L. Cortie.

Note on measures by Professor Barnard of two standard points on the Moon's surface. S. A. Saunder.

Micrometer measures of double stars. William Coleman.

On planning photographic observations of *Eros*. A. R. Hinks.

June 8. Note on a meteoric shower south of *Corvus*. W. F. Denning.

Theory of the motion of the Moon : Part III. Chapter VI. E. W. Brown.

The partial eclipse of the Sun, 1900 May 28, observed at Stonyhurst College Observatory. Rev. W. Sidgreaves.

The partial eclipse of the Sun, 1900 May 28, observed at Norwich. G. J. Newbegin.

Remarks on the total eclipse of the Sun, 1900 May 28, observed at Navalmoral, Spain. Rev. S. J. Johnson.

Inquiry as to the cause of the shadow bands upon the Earth which accompany total eclipses of the Sun. G. Johnstone Stoney.

The partial eclipse of the Sun, 1900 May 28, observed at Armagh. J. L. E. Dreyer.

The partial eclipse of the Sun, 1900 May 28, observed at Forest Lodge, Maresfield. Capt. W. Noble.

The partial eclipse of the Sun, 1900 May 28, observed at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Notes on the total eclipse of the Sun, 1900 May 28, observed at Algiers. E. W. Maunder and A. C. D. Crommelin.

Observations of *Capella* as a double star made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Description of the Durham Almucantar. R. A. Sampson.

Nov. 9. Ephemeris of *Eros*. Frank Robbins.

The partial eclipse of the Sun, 1900 May 28, observed at Col. Cooper's Observatory, Markree. F. W. Henkel.

1900.

Nov. 9. A possible explanation of the Sun-spot period. E. W. Brown.

Discovery and observations of Comet Brooks (*b* 1900). W. R. Brooks.

Nebulæ discovered at the Chamberlin Observatory, University Park, Colorado. H. A. Howe.

Observations of nebulæ made at the Chamberlin Observatory, University Park, Colorado. H. A. Howe.

Note on the formulæ for star corrections. P. H. Cowell.

Observations of the phenomena of *Jupiter's* satellites at Windsor, New South Wales, in the years 1898 and 1899. John Tebbutt.

Note on the accuracy of the star charts published by the French Observatories as reproductions of their plates for the Astrographic Chart. H. H. Turner.

On the appearance of *Saturn's* crape ring in 1900. E. M. Antoniadi.

Observations of *Jupiter* and his satellites made at Mr. Crossley's Observatory, Bermerside, Halifax, during the opposition 1899–1900. Joseph Gledhill.

Photographic measures of the Ring Nebula in *Lyra* and of the neighbouring faint stars. F. P. Leavenworth.

Ephemeris for physical observations of the Moon for 1901. A. C. D. Crommelin.

Note on the Moon's eclipse diameter. A. C. D. Crommelin.

The occultation of *Saturn*, 1900 September 3. Rev. S. J. Johnson.

On the disappearance from photographic films of star images, and their recovery by the aid of a chemical process. Isaac Roberts.

Note on the total eclipse of the sun, 1900 May 28, observed at Algiers. Rev. C. D. P. Davies.

Micrometric measures of the diameter of *Neptune* and distance and position-angle of the satellite, made with the 28-inch refractor at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Corrections to the Armagh Catalogue for 1840. J. L. E. Dreyer.

Occultations of *Saturn*, 1900 June 13 and September 3, observed at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Mean areas and heliographic latitudes of Sun-spots in the year 1899, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

1900.

Nov. 9. On the variable velocity of α Persei. H. F. Newall.

On the near approach of the planet *Eros* to a star (BD+48°, 759). F. A. Bellamy.

Dec. 14. On the connection between solar spots and earth magnetic storms. Rev. W. Sidgreaves.

Watch for the *Leonids*, 1900, at Markree Observatory. F. W. Henkel.

The diameter of the asteroid *Juno* (3), determined with the micrometer of the 40-inch refractor of the Yerkes Observatory; with remarks on some of the other asteroids.

The *Leonids*, 1900 November 14; observations made at Blackheath. E. M. Antoniadi and A. C. D. Crommelin.

The *Leonids*, 1900; observations at the University Observatory, Oxford. H. H. Turner.

Ephemeris for physical observations of *Jupiter*, 1901. A. C. D. Crommelin.

ζ Herculis. T. Lewis.

On the magnitude of the wide companion of *ζ Lyræ*. Rev. S. J. Johnson.

The *Leonids*, 1900; observations made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

On observations of *Capella* as a double star made at the Royal Observatory, Greenwich. W. H. M. Christie.

1901.

Jan. 11. Observations of the *Leonid* meteors of 1900, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On mechanically compensating the rotation of the field of a siderostat. H. H. Turner.

On the accuracy of eye observations of meteors, and the determination of their radiant points. Bryan Cookson.

Leonids observed at Cambridge Observatory, 1900 November 13, 14, 15. J. C. W. Herschel.

On a method of reducing occultations of stars by the Moon; together with the reduction of occultations observed on three occasions at the Liverpool Observatory. H. C. Plummer.

Observations of *Saturn* made at Juvisy Observatory in 1900. C. Flammarion.

Note on the rotation period of *Saturn* in 1896 and 1897. C. Flammarion.

The light curve of *S Arœ*. A. W. Roberts.

1901.

Jan. 11. Observations of occultations of stars and *Saturn* by the moon made at the Royal Observatory, Greenwich, in the year 1900. Communicated by the Astronomer Royal.

Observations of the solar eclipse of 1900 May 28, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

Her Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The Italian Government.
The Norwegian Government.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Camera Club.
Chemical Society.
Geological Society of London.
London Mathematical Society.
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Royal Photographic Society of Great Britain.
Royal Society of London.
Royal United Service Institution.
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Dublin, Royal Society.
Dunsink Observatory.
Edinburgh, Royal Society.
Kew Observatory.
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Baltimore, Johns Hopkins University.
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Basel University.
Batavia, Royal Magnetical and Meteorological Observatory.
Batavia, Natural History Society of Netherlands-India.
Belgium, Royal Observatory.
Berlin, Central International Geodetic Bureau.
Berlin, German Physical Society.
Berlin, Institute of Computation of the Royal Observatory.
Berlin, Royal Prussian Academy of Sciences.
Berne University.
Bogotà Observatory.
Bombay Branch of the Royal Asiatic Society.
Bonn, Royal Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Buda-Pesth, Hungarian Academy of Sciences.
Buda-Pesth, Royal Hungarian Institute for Meteorology and Terrestrial Magnetism.
Calcutta, Asiatic Society of Bengal.
Canada, Geological Survey.
Canada, Royal Society.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Catania, Italian Spectroscopic Society.
Catania, Royal Observatory.
Cherbourg, National Academy of Sciences.
Chicago Academy of Sciences.
Christiania, Norwegian Meteorological Institute.
Copenhagen, Royal Danish Academy of Sciences.
Cordoba, Argentine Meteorological Office.
Cordoba, Argentine National Observatory.
Cracow, Academy of Sciences.
Dijon, Academy of Sciences.
Dorpat, Imperial Observatory.
Egypt, Survey Department.
Geneva Observatory.
Göttingen, Royal Society of Sciences.
Göttingen, Royal Observatory.
Groningen, Astronomical Laboratory.
Halifax, Nova Scotian Institute of Sciences.
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Harvard College Astronomical Observatory.
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Helsingfors, Society of Sciences of Finland.
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Kasan, Imperial Observatory.
Kasan, Imperial University.
Kiel, Royal Observatory.
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Melbourne, Government Observatory.
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Padua Observatory.
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Paris, Bureau of Longitude.
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Paris, Philomathic Society.
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Philadelphia, Franklin Institute.
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Pola, Meteorological and Magnetical Observatory.
Potsdam, Central International Geodetic Bureau.
Potsdam, Royal Prussian Geodetic Institute.

Poughkeepsie, Vassar College Observatory.
Poulkowa Observatory.
Prague, Imperial Observatory.
Queensland Branch of the Geographical Society of Australasia.
Rio de Janeiro Observatory.
Rome, Pontifical Academy *de' nuovi Lincei.*
Rome, Royal Academy *dei Lincei.*
St. Petersburg, Imperial Academy of Sciences.
St. Petersburg, Russian Astronomical Society.
San Fernando Observatory.
San Fiel College, Portugal.
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Stockholm, Royal Swedish Academy of Sciences.
Sydney, Royal Society of New South Wales.
Tachkent, Astronomical and Physical Observatory.
Tacubaya, National Astronomical Observatory.
Toronto, Astronomical and Physical Society.
Toronto, Canadian Institute.
Toulouse, Astronomical Observatory.
Turin, Royal Academy of Sciences.
Turin, Royal Astronomical Observatory.
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Upsala, Royal Society of Sciences.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Austrian Geodetic Bureau.
Vienna, Imperial Ministry of Marine.
Warsaw Astronomical Observatory.
Washington, National Academy of Sciences.
Washington, Office of the American Ephemeris.
Washington, Smithsonian Institution.
Washington, United States Naval Observatory.
Yerkes Observatory.
Zürich, Central Meteorological Institute of Switzerland.
Zürich, Society of Natural History.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."
Editors of the "Astrophysical Journal."
Editor of the "Athenæum."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."
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ADDRESS

Delivered by the President, Mr. E. B. Knobel, on presenting the Gold Medal of the Society to Professor E. C. Pickering.

The Council have awarded the gold medal to Professor Edward Charles Pickering "for his researches on Variable Stars and his work in Astronomical Photography," and it is now the recognised duty of your President to submit to you some of the considerations which have actuated them in selecting the distinguished Director of Harvard College Observatory as the recipient of their highest honour.

In attempting to lay before you an outline of the work of our Medallist in the above directions, I am very conscious of the great difficulties attendant upon an adequate presentation of the claims of an astronomer who, combining enthusiasm with devotion, and fertility in resource with surpassing skill, possesses in an eminent degree a comprehensive intellect to disentangle and elucidate, coupled with a power of organisation to carry his enterprise to a successful issue.

It may be truly said that the successful practical astronomer of the present day must possess much greater versatility in his qualifications, and more varied knowledge of the kindred sciences, than would a generation back have been deemed adequate for profound research. The striking advance witnessed during the latter part of the nineteenth century in novel devices in the construction of astronomical instruments, the enormous power for advancing knowledge which has accrued from the development of spectroscopy and photography, have all brought additional claims upon the energy and intelligence of the modern astronomer, which, to ensure success, have to be satisfied and fulfilled.

The study of the extensive researches and varied observations of our Medallist reveals the lucid and vigorous mind that has been applied to the solution of so many difficult problems, and demonstrates the skill and energy which have enabled him to obtain a complete mastery over the processes necessary for the accomplishment of his designs.

The long series of volumes of the *Annals of Harvard College Observatory* published in the past twenty-five years record a wealth of original research far beyond the limits of an address to

epitomise. On a former occasion the occupant of this chair addressed you on the splendid work accomplished by Professor Pickering in stellar photometry, and I shall hope later on to make some reference to his more recent researches in this direction. There is obviously no finality in astronomical observation, and Harvard teaches us that whether it be a photometric or a photographic survey of the heavens, the work is repeated and revised again and again to correct errors and to record changes and variability which might otherwise escape notice.

Professor Pickering's researches on variable stars date from the commencement of his directorship of Harvard Observatory in 1876. In his first annual report he announces his intention to undertake the extensive work of reducing Argelander's comparative observations of variable stars, by measuring the brightness of the comparison stars, and thus to determine the true brightness of the variables as given in the immense mass of Bonn observations—a work which he published some years later.

His first paper on the subject was published in 1880, wherein from careful mathematical reasoning he proves that the variability of stars of the *Algol* type is due to a non-luminous body revolving round the star ; and the results he obtained for the ratio of the diameters of *Algol* and its satellite are very closely accordant with those announced by Vogel nine or ten years later from the Potsdam spectroscopic observations.

A further memoir, which appeared the following year, is extremely suggestive. In considering those variable stars whose light is continually varying, but whose changes are repeated with great regularity in a period not exceeding a few days, his reasoning is of this form :—

Admitting a common origin of the stars of the *Milky Way*, a general coincidence in their axes of rotation is not improbable, especially as such an approximate coincidence occurs in the members of the solar system. If the coincidence were exact, the direction must be that of the poles of the Sun, or approximately that of the pole of the ecliptic. On the other hand, since the stars of the *Milky Way* are supposed to be arranged in the general form of a flattened disc, we should more naturally expect that the axes of rotation would be symmetrically situated with regard to it, or would coincide with its shortest dimension. According to this theory, the axes of rotation would be directed towards the poles of the *Milky Way*.

If we suppose that a great number of variable stars were distributed over the heavens, it is evident that those seen in the direction of their axes would not appear to vary, since, as they turned they would always present the same portions of their surfaces to the observer. Those at right angles to this direction would show the greatest variation, and would appear to be more numerous, since they would be more likely to be detected. If, then, the axes are coincident, we should expect that most of these variable stars would lie along the arc of a great circle, whose

pole would coincide with their axes of rotation. As a fact, eighteen such variable stars are found to be in a great circle very nearly coincident with the *Milky Way*. And upon this result Professor Pickering sagaciously indicates a method of discovering variable stars of this class by observation of certain parts of the sky.

Numerous early papers on variable stars must necessarily be passed over on the present occasion, but in this domain of observational astronomy it may be interesting to give an example of the indefatigable assiduity of our medallist.

In a photometric study of *β Persei*, he records having made on thirteen nights 2748 comparisons with the neighbouring star *ω Persei*, of which six hundred were made in a single night. On that occasion the observations were continued almost without intermission for $8\frac{3}{4}$ hours. Again, in a similar study of Ceraski's Variable (D. M. 81°—25), he made 3276 comparisons on five evenings, of which nine hundred were obtained on a single night, the probable error of a single minimum determined in this way being only 1·3 minutes.

It was, of course, the development of the photometers he had devised and perfected with so much skill that permitted the acquirement of such a mass of observations, and from the above quotation it would seem that quick-firing weapons are as necessary for attacking celestial problems as for some others of a less peaceful nature.

The study of variable stars is obviously a photometric research, and allusion should therefore be made to some of the more recent processes employed by Professor Pickering in his work. Herein it is noteworthy to mention his ingenious adaptation of Professor Pritchard's Wedge Photometer, to be used as a transit photometer for determining the magnitudes of stars too faint to be measured by the Meridian Photometer. This instrument consisted of an ordinary wedge of tinted glass cemented to a glass plate carrying an opaque bar parallel to the thinner end of the tinted wedge. The plate is placed in the focal plane of the telescope, and the bar is made coincident with an hour circle. The interval between the transit of a star across the bar and its disappearance in the wedge is the observed quantity from which the brightness of the star is deduced. The thirteenth volume of the *Harvard Annals* contains a catalogue of 4143 stars from the 8th to the 14th magnitude, whose brightness was determined by this most ingenious arrangement.

It was at Harvard College Observatory that the birth of stellar photography took place in the year 1850, when Bond and Whipple succeeded in obtaining satisfactory images of bright stars on a daguerreotype plate. It was natural, therefore, that Professor Pickering should early avail himself of the immense aid to astronomy afforded by the invention of the photographic dry plate to assist his researches on variable stars and stellar photometry.

In a highly interesting memoir on stellar photography published in 1886, he pointed out that the different photometric processes which hitherto had been used in determining the light of the stars, give results which differ systematically when large variations in light are to be measured. This is not due to a difference in the assumed value of the unit of the scale of magnitudes, but to an actual difference in the measurement of the amount of light. He suggests that photography affords an excellent means of determining systematic differences in photometric catalogues, as the errors in that case will be of a very different kind. To carry this into effect, he points out the advantages that will accrue from photographing stars without moving the telescope. Thus each star by the diurnal motion will form a trail upon the plate. Such trails will appear as lines whose intensity is perfectly uniform within the limits of accuracy of which the comparison is capable ; and he found that small differences in light are much more perceptible in the trails than in the circular images obtained when the telescope is driven by clockwork. In his hands this original method assumes a considerable scientific value. For the brighter stars, even when near the Equator, a trail is formed when the camera is stationary ; for others less bright the duration of the transit can be regulated as need requires. It is obvious that as the stars approach the pole the trails made during a given exposure become shorter, and the photographic action is lengthened, so that when the camera is pointed to the pole trails of stars as low as the 14th magnitude can be easily photographed.

The method of trails was applied not only to the photometry of stars, but also in a most interesting and instructive way in photographing stellar spectra, referred to later on.

The mode of determining the magnitudes from trails was to compare the trail of a star whose brightness had been obtained in various ways, with the trails of those stars whose magnitude was sought. Obviously there must be systematic differences in the magnitudes of stars determined by visual and by photographic methods, and the comparisons instituted clearly indicated such differences. The evidence showed that for stars brighter than the fifth magnitude the numerical photographic magnitudes are in excess of the photometric magnitudes by one unit, and in faint magnitudes the reverse condition holds, as is possible from other considerations which cannot well be dwelt upon here. In an exhaustive discussion, Professor Pickering indicates the many advantages presented by this interesting method for determining not only the brightness but also the position of stars.

In endeavouring to give you some idea of the skill, vigour, and enterprise which characterise our Medallist, I would now pass to that magnificent work which has been organised and carried into such successful execution by him, under the title of the Henry Draper Memorial—a work which has given some of the most brilliant results for our admiration.

The numerous researches undertaken at Harvard College Observatory have needed not only a corps of highly skilled observers, but also an array of instruments of various kinds and various calibres; all for their efficient use requiring considerable funds. To the great honour of Professor Pickering's countrymen and countrywomen, the value of his researches has been perceived and justly appreciated, and by means of much generous pecuniary assistance he has been enabled to accomplish schemes which he rightly considered would advance our science.

But this, we are happy to recognise, is not singular in a land where there is such keen appreciation of all enlightened and intellectual methods, where there is continual striving towards high ideals in philosophy and science, and where there are so many generous benefactors ready to give princely sums to found colleges, to establish observatories, and to encourage in every way the pursuit and advancement of knowledge.

The work alluded to above has been effected by the liberal provision made by Mrs. Draper in 1886 for carrying on researches in Stellar Spectroscopy, as a memorial to her late husband, Professor Henry Draper, who was so successful a worker in the new lines of research which the development of the spectroscope and of photography had opened out.

Her beautiful idea was framed to embrace a complete discussion of the constitution, the conditions and the physical properties of the stars as revealed by their spectra. It is difficult to conceive a more appropriate way of hallowing the memory of a distinguished man, than by efforts to enlarge and enrich the science in which he laboured and to which he was so devoted. Accordingly, in placing that trust in Professor Pickering's hands, he was supplied with instruments suitable for the undertaking, and with funds sufficient to enable him to carry the work into execution.

The results hitherto published are contained in three volumes of the *Harvard Annals*, besides numerous circulars and shorter papers describing specific discoveries. The investigations were planned to cover the entire sky, and when, in the course of a few years the scheme was fully developed, four telescopes were established for the observations—two at Cambridge for the northern hemisphere, and two at Arequipa, in Peru, at an altitude of 8000 feet, for all stars too far south to be observed at the former observatory. The principal instrument at each station was an 8-inch photographic doublet of large angular aperture and short focal length, permitting photographs to be obtained extending over a region 10° square. In addition to these, an 11-inch refractor was employed at Cambridge and a 13-inch at Arequipa. The dispersion in all cases was obtained by one or more prisms over the object-glass, which could be conveniently removed to allow of the instrument being used for ordinary stellar photography.

The magnificent volume which embodies the principal results

has been appropriately entitled *The Draper Catalogue.* When we learn that herein are contained the details of the spectra of 10,351 stars, deduced from the measurements of 28,266 spectra, we can form some idea of the magnitude of Professor Pickering's operations, and appreciate his inspiriting influence on all those who so ably assisted him in completing this portion of the work. Particularly is it interesting to see the important part of the work undertaken by lady assistants, one of whom—Mrs. Fleming—is entitled to our gratitude, as from her minute and accurate examination of the photographs she has been able to announce some of the most interesting discoveries in variable stars and stars with peculiar spectra that have been recorded.

In photographing the spectra, the prism with a reflecting angle of 13° was adjusted so that its refracting edge was placed perpendicular to the axis of the earth. The spectrum of the star formed a line on the plate ; then, by altering the rate of the driving clock this line was allowed to trail slowly over the plate to give an image of a desired width. By this elegant means spectra were obtained of all stars down to the seventh magnitude, of such dimensions that they could be studied and classified. Hitherto the method of using a narrow slit, supplemented or not by a cylindrical lens, and requiring extreme accuracy in the driving clock, and even then a continued personal vigilance for the manual correction of its irregularities, has proved a most serious drawback in the register of stellar spectra by the aid of photography. By the method of trails, the slit, the cylindrical lens, and the painful watching are dispensed with, and, as has been well remarked, "the light of the star itself, by diurnal motion, becomes virtually a line of light or illuminated slit, which is dispersed into its spectrum by the refracting prism." We may well admire the beauty and simplicity of this method, so essentially practical, and so capable of yielding a mass of results available for leisurely study. It undoubtedly marks a distinct advance in photographic astronomy.

The spectra in *The Draper Catalogue* are classified in an original and somewhat minute manner. Secchi's type I., the Sirian stars, are subdivided into four varieties. The solar stars, type II., into eight varieties. The third type is not subdivided, and it would seem that the difference between this and the second type is much less marked in the photographic than in the visible portion of the spectra. The fourth type of red stars are absent. A separate classification is given to stars with bright lines, and planetary nebulæ, which Professor Pickering considers as together forming a fifth type.

One remarkable result appears from the study of this valuable catalogue. Practically two-thirds of Milky Way stars are found to be Sirian stars, belonging to type I., thus confirming to a certain extent Kapteyn's discovery that "stars of the Milky Way are in general bluer than the stars in other regions of the sky ;" in other words, that they are photographically more brilliant.

In Professor Pickering's careful discussion of every feature of *The Draper Catalogue* one is rather bewildered by the multitude of original and far-seeing thoughts deduced from the study of the spectra of the whole heavens. One striking conclusion may be here mentioned : that, with few exceptions, all the stars may be arranged in a sequence, beginning with the planetary nebulæ, passing through the bright-line stars to the *Orion* stars, thence to the first type, and by insensible changes to the second and third type stars ; and he adds, "the evidence that the same plan governs the construction of all parts of the visible universe is thus conclusive."

But what has already been published in *The Draper Catalogue* does not represent one-half of what has been accomplished ; for we learn that there exists, as yet unpublished, a second *Draper Catalogue*, giving the spectra of 30,000 stars down to the eighth magnitude, from the north to the south pole, a mass of material from which we may anticipate many valuable lessons and unexpected discoveries.

One of the principal objects of the Henry Draper Memorial was to investigate the physical constitution of the stars, and in the first instance their relative magnitudes. For this purpose photographs of three kinds were obtained—viz. trails, circular images, and spectra. The first of these has already been alluded to. In the second method, when the telescope was driven by clockwork to give circular images, the scale for determining magnitudes was obtained by taking a series of exposures on a given cluster of stars, moving the telescope slightly in right ascension after each one. Professor Pickering had found that Pogson's ratio of 2·5 for a difference of one magnitude was too low for photographic magnitudes, and that three times the exposure would bring the results more in accord with visual magnitudes. Accordingly, each exposure in the above series was one-third less than that preceding, and thus the scale for comparison was formed.

With regard to the determination of relative magnitudes from the spectra, the very original and interesting plan was adopted of comparing the density of the photographed spectra in the vicinity of the G line with a prepared scale of densities. The measurement of relative brightness between two stars differing materially in colour is very imperfectly obtained by visual methods. Indeed, Wilhelm Struve doubted whether it would ever be possible for photometry to decide which was the brighter of two stars differing in colour, such as *Arcturus* and *Vega*. The ingenious method of Professor Pickering, though it is limited to measuring the brightness of stellar light of a particular refrangibility, is nevertheless a most important step in a new direction for comparing magnitudes, and opens out some interesting ideas for our consideration. In addition to what we have already in our hands, Professor Pickering has prepared the material for an investigation of the photographic brightness of 40,000 standard

stars of about the tenth magnitude, which we hope may shortly be given to the world.

The discussion and comparison he subsequently undertakes, of different methods of ascertaining the brightness of stars, shows naturally very conflicting results ; and he concludes that the determination of the true relative brightness of the stars, either visually or photographically, is a much more difficult problem than would appear at first sight. It must be left to future investigators to decide which of the various processes employed gives the correct result. The spectra in *The Draper Catalogue* were all photographed with the 8-inch telescopes and were on a small scale. For bright stars the 11-inch telescope was used, giving spectra on a much larger scale—the results of which are published in a separate volume, and discussed by Professor Pickering with his usual acumen. At Arequipa similar work was undertaken with the 13-inch telescope.

The 8-inch telescopes were also employed in star charting. With these instruments photographic charts of the entire sky from the north to the south pole have been obtained every year, showing all stars brighter than the thirteenth magnitude.

The photographs obtained up to the present time by the four telescopes employed in the Henry Draper Memorial amount to the astounding figures of 52,229 plates taken with the two 8-inch telescopes, 12,872 with the 11-inch, and 10,214 with the 13-inch. When we bear in mind that these figures signify repeated surveys of the whole heavens—spectrographic, photometric, and photographic—extending continuously over several years, we cannot fail to realise the enormous treasure thus stored up for us by the Harvard Observatory.

The resources at Professor Pickering's disposal were very materially increased in the year 1889 by the generous gift of a large sum of money from Miss Bruce, of New York, for a 24-inch photographic telescope, "to be used under favourable climatic conditions in such a way as in the judgment of Professor Pickering would best advance astronomical science."

The establishment of a branch of Harvard College Observatory in the southern hemisphere, at the high altitude of Arequipa, in Peru, is a conspicuous instance of the Director's foresight of the necessities of modern astronomy to reduce the climatic difficulties of low-lying stations ; and it was also a magnificent and unique idea to bring the whole stellar universe thus within his grasp. Accordingly, when the Bruce telescope was constructed, it was mounted at Arequipa, where it has been in regular use on special lines of research. Up to last year nearly 5000 photographs had been taken with it of planets, asteroids, nebulæ, and particular star fields.

One triumph of this telescope has already been announced by Professor William Pickering in the apparent discovery of a new satellite to the planet *Saturn*. This object is extremely small and faint, and we await at the moment confirmatory observations.

Among so many noteworthy features of our Medallist's work, there is, perhaps, no one more remarkable than the exceedingly ingenious instrument he invented for automatically charting the heavens. This instrument automatically photographs all stars down to the sixth magnitude as they transit during the night. It consists of a doublet of 6 inches aperture and about 2 feet focal length, mounted so as to make a complete circle of the meridian every twenty-one minutes. A clock automatically starts the movement, and the camera revolves in steps of 2° every two seconds until it has completely covered the meridian, an operation which takes six minutes. After an interval of a quarter of an hour the operation is repeated. At the end of three hours, during the half revolution, when the instrument is pointing to the Earth, the plate is shifted automatically, and the instrument got ready for the next exposure. The two seconds exposure is enough to photograph all stars down to the sixth magnitude, and all these are registered on the plate. Any new star or remarkable variable rising above the sixth magnitude, or any comet of equal brightness, would be recorded on these plates. Truly the ingenuity of such an arrangement must claim our interest and admiration.

To turn now to the discoveries that have resulted from these various researches, we do not find that that admiration is in any way limited.

The classification of stars according to their spectra is so far-reaching that Professor Pickering thinks it should be applied to each of their other properties. Of the variable stars, it appears, as we have said, that all known *Algol* stars have spectra of the first type, while long-period variables in general are of the third type, and have the hydrogen lines bright when near their maxima. This property has led to the discovery of numerous objects of this class, and no exception has been found of a star having this spectrum whose light does not really vary. Up to 1893 twenty new variable stars had been so discovered. Again, in variables of long period discovered visually, over forty have the hydrogen lines bright. Of such long-period variables, however, his photographic discoveries transcend those made visually. Some 150 of these variables have been discovered from the photographic plates, and the measurements and reductions of at least one-third have already been completed from about 100 plates of each star.

The Harvard circulars from 1895 to the present time contain numerous announcements of discoveries of variable stars from the examination of their spectra. The accounts are surprising indeed. Peculiarities in the spectrum of a particular star attract the attention of that most careful observer, Mrs. Fleming. Eighty-seven photographs of that region during the previous nine years are examined without trace of the star; then it appears in eight more recent photographs, and the existence of a new star is established. Or, if we take the case of a new *Algol* variable being discovered elsewhere, Professor Pickering immediately finds that

that region had been covered by 195 plates, all showing the spectrum of the star in varying degrees of brightness, and enabling the period of variability to be determined with a probable error of only one or two seconds. The minor planet *Eros* was discovered by Witt on 1898 August 13, but the examination of the Harvard photographs enabled Professor Pickering to announce that it could be detected on fifteen or sixteen plates taken from 1893 to 1896, and that the spectrum photographed in January 1894 was, like that of other planets and the Sun, of the second type. A remarkable photograph taken in February 1894 shows the planet as a long trail, while the images of stars are round. An ingenious method of photographing this planet when it was too faint to be observed in other ways was adopted last year. An eyepiece was connected with the photographic plate by means of a micrometer screw. A star was followed by means of the eyepiece, while a motion equal to that of *Eros* was given to the plate. On the plates the stars formed trails, while *Eros* appeared as a circular image.

Fourteen new stars have been discovered since 1572, when Tycho discovered the celebrated one in *Cassiopea*. Four of these were discovered by the Harvard photographs, viz. *Nova Normæ*, *Nova Carinæ*, *Nova Centauri*, and *Nova Sagittarii*, and in proof of this Professor Pickering has submitted copies of his photographs of the regions at different dates, showing in each case on the latter date a bright star which was non-existent at the earlier. With regard to the new star discovered by Anderson in February 1892 in the constellation *Auriga*, commonly called *Nova Aurigæ*, the earliest records are found upon the Harvard plates.

Eighteen photographs of the region taken with one of the 8-inch telescopes from November 1885 to November 1891 showed no trace of the star, though stars of the thirteenth magnitude were visible; but on plates exposed December 16 1891 to January 31 1892 the *Nova* is clearly shown as a fifth magnitude star. With the automatic instrument described above, plates were exposed on the region from October 21 to December 1, 1891, without indicating the *Nova*, but those exposed by the same instrument December 10 1891 to January 20, 1892, exhibit the new star quite clearly. That is to say, it was distinctly photographed by Professor Pickering six or seven weeks before its discovery by the Edinburgh astronomer.

Again, eight photographs taken in 1887 show a star in *Perseus* with bright hydrogen lines. No trace of such star is found in eighty-one photographs taken in the subsequent eight years. It is therefore proved that a new star blazed out in *Perseus* in the year 1887, which would have eluded observation altogether but for these priceless Harvard records.

Perhaps there is no more surprising discovery due to the organisation of the Henry Draper Memorial than that announced by Professor Bailey, the astronomer in charge of the Arequipa Observatory, that numerous globular clusters contain an extra-

ordinary number of variable stars. In the dense cluster ω *Centauri* there are 128 variable stars; in Messier 3, 132; in Messier 5, 85; and in Messier 15, 51. And as proof of the exhaustless manner in which such remarkable discoveries are investigated, we learn that Professor Pickering is already preparing for the press a series of 30,000 observations of the variable stars in the cluster ω *Centauri* alone.

The Arequipa photographs, from the careful examination of Mrs. Fleming, reveal that there are numerous stars which have peculiar spectra unlike any other stars. The spectra contain lines which are apparently due to some elements quite unknown in other stars, or on the Earth, and we have here a new field opened out for research.

These interesting discoveries afford food for prolonged study and consideration, but one result of the boundless energy of Professor Pickering is to forestall future discovery. No one will be able to claim the discovery of a new variable, or a new star, until he has satisfied himself that Harvard has not anticipated him by its numberless photographic records. All the more honour, however, to that observatory that it should have laid up stores of such valuable photographs, the examination of which cannot but increase our knowledge of the nature and distribution of the stars, and expand our ideas of the construction of the heavens.

The consideration of Professor Pickering's work in astronomical photography would not be complete without some, though on this occasion very brief, mention of his interesting photographic determination of the laws of atmospheric absorption—a question of capital importance in the photometric researches already alluded to. By photographing the trails of stars at upper and lower culmination on the same plate, with a certain system of exposures, data were obtained capable of yielding a value for the coefficient of absorption in fair agreement with determinations previously made with the Meridian Photometer.

It remains for me to say one word respecting our Medallist's recent work with the Meridian Photometer. Not only has the work known as the *Harvard Photometry* been completely revised and the magnitudes re-measured, but the same instrument as used in some of the earlier observations, was sent to Peru, and in the capable hands of Professor Bailey it was used to determine the photometric magnitudes of the whole of the southern hemisphere in the same way as it had been employed for the northern.

Thus, Professor Pickering has completed a photometric survey on a uniform plan of the whole heavens, involving a million observations; and, as we already know, he has also accomplished a photographic determination of brightness with uniform instruments for both hemispheres.

I venture to sum up his work in the following citation, which

expresses in far better words than I can employ the abstract of his labours :—

"Harvard College Observatory is a wonderful focus of activity, in which one hardly knows whether he ought most to admire the exhaustless energy or the admirable ingenuity which he finds displayed in it. Its work has been aided by gifts which have no parallel in the liberality that prompted them. Yet without energy and skill such gifts would have been useless. The activity of the establishment includes both hemispheres. Time would fail to tell how it has not only mapped out important regions of the heavens from the north to the south pole, but analysed the rays of light which come from hundreds of thousands of stars by recording their spectra in permanence on photographic plates. The work of the establishment is so organised that a new star cannot appear in any part of the heavens, nor a known star undergo any noteworthy change, without immediate detection by the photographic eye of one or more telescopes—all-seeing and never-sleeping policemen—that scan the heavens unceasingly while the astronomer may sleep, and report in the morning every case of irregularity in the proceedings of the heavenly bodies."

Time, however, will not permit me to offer all the evidence that might be adduced in support of the plea I have been urging. The task of doing full justice to a multitude of researches, so varied and original, and so replete with interest, is a very difficult one; but notwithstanding this inadequate and imperfect presentment of the labours of our illustrious Associate, I trust I have at least succeeded in satisfying you that he has fully merited the recognition the Council have accorded him.

The history of the award of the Gold Medal is the history of men who have made an indelible mark in astronomy—whose labours have stimulated and pioneered others in the path of success, and whose disciples have expanded and developed the principles which they enunciated, to the realisation of such progress in astronomical science as we are witnessing at the commencement of the twentieth century. Among such a roll of distinguished men, Professor Pickering will surely take an honourable place, as a brilliant leader, who, with rare skill, unwearied energy, and consummate ability, has known so well how to instigate, how to organise, and how to accomplish.

The President, addressing the American Ambassador, said :

Mr. Choate, I beg to thank your Excellency for the honour you have done the Royal Astronomical Society this day in so kindly appearing here to represent the distinguished Director of Harvard College Observatory.

In handing you this medal for conveyance to Professor Edward Charles Pickering, I beg you to assure him of our high

appreciation of his remarkable labours in stellar astronomy, and our continued interest in the important institution he so ably directs. We do not suppose that one who has displayed an unwearied activity throughout his whole career can need any such stimulus to nerve him to increased efforts for the advancement of our science ; we only trust he will believe that, in offering him the highest honour in our power, we feel that we shall be equally honoured by his acceptance of it.

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :—

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